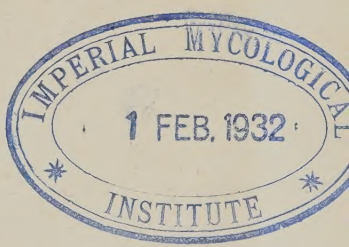
RUBBER RESEARCH INSTITUTE

OF

MALAYA.

Quarterly Journal Vol. 1.

Subject Index



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RUBBER RESEARCH INSTITUTE OF MALAYA.

QUARTERLY JOURNAL VOL. 1.

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NOTE.

With reference to the Foreword in Bulletin No. 1: "The Natural Coagulation of Hevea Latex," the researches attributed to the former Research Department of the Société Internationale de Plantations et de Finance were carried out by Whitby in the Research Department of the Société Financiére des Caoutchoucs.

ERRATUM.

Quarterly Journal Vol. I, Nos. 1 and 2, page 72.

In the para (d) on "Insufficiency of sodium bisulphite," the standardisation of the latex in the case of pale crepe should be 2 lbs. of dry rubber per gallon and not $1\frac{1}{2}$ lbs. as stated.

NOTES ON THE DEVELOPMENT AND WORK

OF THE

RUBBER RESEARCH INSTITUTE OF MALAYA.

The following brief notes summarise the progress to date of the work and organisation of the Institute and are published for general information pending the more detailed account which will be given in the Annual Report.

The Director of the Rubber Research Institute arrived in Malaya to take up duties on 26th September, 1926.

In view of the general recognition of the very considerable start in time that research associations in other countries had gained it was regarded as urgent that the Institute should press forward with the greatest speed in getting a staff together, in providing the necessary house accommodation and in finding laboratory accommodation.

Staff.

At this time the greatest difficulty was being encountered by Colonial Agricultural Departments in obtaining research officers to fill existing vacancies. Attention was drawn to this serious shortage and the matter was discussed as a problem of major importance at the Imperial Conference of October 1926 (Cmd. 2768 p. 48) and by Lord Lovat's Committee on Agricultural Research (Cmd. 2865 pp. 15—26). The securing of staff was therefore regarded as the greatest problem. It had from the first been recognised that the Institute, in order to cope with the problems of the Industry, must provide more fully for botanical and soils work than had heretofore been done and that the pathology and chemical sides must be adequately staffed to allow the necessary research and advisory work to be undertaken.

The staffing of the Institute presented some difficulty as home candidates would necessarily have to be appointed without interview by the Director. The Institute was fortunate in securing as Heads of the Botanical Division, Chemical Division, Pathological Division and Soils Division, Mr. F. Summers, Major B. J. Eaton, Dr. J. R. Weir and Dr. W. B. Haines, and it is in-

debted to Mr. Summers for securing staff from home. The full list of staff is given in the Staff Distribution list, with the dates of assumption of duty (p. 8).

In November, 1926 Major B. J. Eaton was appointed Head of the Chemical Division and to which Division Mr. R. G. Fullerton was appointed in December, 1926. Mr. A. R. Sanderson and Mr. H. Sutcliffe were appointed to the Pathological Division in November, 1926. These were local appointments.

Mr. Summers, Dr. Haines and Dr. Weir arrived in Malaya in June, 1927, and the two former officers paid a visit to the research stations in Sumatra in August of that year. Dr. Weir visited Sumatra in June of 1928. The Director visited Sumatra in November, 1926, and Java in July, 1927, to study the work and organisation of research stations in those places.

The following members of the staff arrived later in June, 1927:—Mr. C. E. T. Mann, Dr. E. Rhodes, Dr. A. S. Corbet, Mr. F. Billington, Mr. N. C. Jenkins and Mr. F. Beeley.

The three last named officers are the Field Officers and, as it was necessary that they should acquire field knowledge of work on rubber estates, arrangements were made for them to go out and live on estates for a period of three months. The Institute is much indebted to the Estate Managers who kindly arranged to have them on the estates under their charge.

The other members of the staff assumed duty as under:—

Mr. L. E. Morris in November 1927.
Mr. D. S. Gardner in December 1927.
Mr. H. Gunnery in January 1928.
Dr. C. F. Flint in February 1928.
Mr. V. L. Cachemaille in April 1928.
Mr. P. S. Hudson in November 1928.

In the two years from November, 1926 to October, 1928 the Institute has thus had research staff as under:—

3	officers	for 24	months
4	,,	,, 23	,,
13	,,	,, 16½	,,
14	,,	,, 12	,,
16	,,	,, 10	,,
17	,,	,, 9	,,

Bungalow Accommodation.

House accommodation for members of the staff was provided for by the purchase of three bungalows and by the building of fourteen new bungalows, of which the last group of five are now ready for occupation.

Laboratory Accommodation.

To provide working accommodation for the staff without undue delay it was necessary to take over a suitable building. It was accordingly decided that the bungalow which forms part of the present Laboratory building should be taken over and extended or modified as required.

This entailed building operations both within and without the old bungalow structure. During these operations the staff worked under difficult conditions as to noise and accommodation. This period, however, was of essential importance to the rapid development of the work of the Institute in that it permitted the early completion of much preliminary work which had to be accomplished before research proper could be inaugurated and in particular it enabled the staff to become acquainted with previous research work on rubber, to acquire at first hand a knowledge of the rubber growing industry and its problems, and to pool suggestions for furnishing the Laboratory with the equipment and apparatus best suited for the special needs of each branch of the work of the Institute.

In this connection the Institute is indebted to Major Eaton and Dr. Haines for valuable suggestions and detailed plans in connection with laboratory equipment and to Mr. Morris and Dr. Rhodes for work in connection with the library and the arrival of apparatus.

Programmes of Work.

As a result of the experience gained and in the light of their research experience, Heads of Divisions were able to draw up their Programmes of Work and submit them to the Board some four months after their arrival in Malaya. The Programmes of Work were considered and discussed by the Research Committee of the Board, at which the Hon. Mr. H. E. Nixon and Mr. W. Miller Mackay were present as co-opted members.

Organisation Report.

At the same meeting of the Board the Director submitted his Organisation Report.

Experiment Station.

In the early part of 1927 negotiations were started in connection with the acquisition of an area of land for an Experiment Station. After consideration by Government of memoranda by the Director and by the Conservator of Forests and following a discussion between Government and the Board Government agreed to make available 2,000 acres of land in the Sungei Buloh Forest Reserve. Mr. D. S. Gardner, the Manager, was appointed in December, 1927, and under him opening up work has been rapidly pushed forward. A planting programme and the plot lay-out have been drawn up to meet the field requirements of investigations by the research staff. Some 490 acres have been felled of which 200 acres have been cleared. Planting has been completed on the fertiliser trial plots and is proceeding on other plots including that for the collection of pedigree strains of Hevea. Nurseries for various special purposes are now being established.

Summaries of Work.

The Summaries of Work in hand prepared by the Heads of Divisions, indicate very briefly the progress made in certain lines of investigation. The summaries of this research work cannot with advantage be further condensed, and reference should be made direct to the notes prepared by the Heads of Divisions (p. 9).

Experimental Work on Estates.

An important volume of experimental work on estates has been carried out. Over 60 estates have been given assistance in their budding programmes, several experimental areas have been laid down, and experimental observations have been made in many directions. The Pilmoor Clones work is a field experiment of major importance.

The coagulation and preparation of rubber have given rise to several problems which required experimental work to determine the nature of the trouble and treatment.

A field experiment of major importance on the transmission of root diseases is in hand over a large area on an estate where facilities have been granted to the R.R.I. for this investigation.

Over 80 soil samples have been analysed and 20 field experiments (mainly on manuring) are in progress from which the data are examined and summarised by the Institute.

Visits to Estates.

A total of 262 visits have been paid to 213 estates in all parts of Malaya from Kelantan to Singapore Island, in connection with the development of the work of the Institute and with the investigation of particular estate problems.

Correspondence Analysis.

In the two years ending October, 1928 the total number of letters received on the research side of the Institute was 4633. Letters despatched from both the research and administrative sides in the same period numbered 7275. Of the letters received 2623 were enquiries from estates on estate problems. They covered a wide range of subjects, the outstanding items being as follows:—

Smoked Sheet	...	463 enquiries.
Tree Injury by External Agents	...	238 ,,
Fungous Diseases of Rubber	...	248 ,,
Brown Bast	...	155 ,,
Manuring	...	339 ,,
Budding	...	285 ,,

In many cases these estate enquiries entailed laboratory investigation or observation for periods varying from a few hours to several months. The detailed analysis of estate enquiries is given as some indication of the range of subjects on which advisory work has been done.

Lectures Analysis (p. 19).

Lectures delivered in the period February, 1927 to October, 1927 totalled 46. Those were given before District Planters' Associations, before the Incorporated Society of Planters at its Annual Conference and before branches of the Incorporated Society of Planters.

Demonsirations and exhibits have been given at exhibitions at Kuala Lumpur, Ipoh and Teluk Anson, and before the Incorporated Society of Planters at Port Dickson.

Publications.

Two Manuals have been published:—

(1) "Guide to the Preparation of Plantation Rubber" by B. J. Eaton.

(2) "Budding of Hevea in Modern Plantation Practice" by F. Summers.

The manuscript of Manual No. 1 has been prepared for translation into Chinese and has been forwarded to the Agricultural Department for publication in the Chinese Agricultural Journal.

Major Eaton has summarised the replies received to a questionnaire on the use of Alum as a Coagulant, and his report has been published in the R.G.A. Bulletin.

Several of the lectures given have been prepared for publication in newspapers and "The Planter" in Malaya.

Smallholders.

Arrangements have been made with the Agricultural Department for the publication, in Malay and Chinese journals, of advisory and informative matter for smallholders.

Arrangements have also been made to co-operate in work on behalf of smallholders with existing agencies, i.e., the Cooperative Societies Department with its Rubber Advisory Officers and the Agricultural Department with its Inspection Staff. Having in view the work of these existing agencies it was concluded that the work of the Rubber Research Institute could most effectively be applied on behalf of smallholders in the direction of scientific investigation into their problems. Advice emanating from the Rubber Research Institute and based on these investigations would then be communicated to officers of the Co-operative Societies Department and transmitted by them to the smallholders.

Library and Information Bureau.

The foundations of an adequate library have been laid and a library exchange list of some 120 names has been built up.

An Information Bureau is being established, the object of which is to keep an index of all the important literature on the subject of rubber. It will take the form of a card catalogue and will, it is hoped, be of great use to workers in all fields of rubber

research; it will later become available to all those outside the Institute who care to submit any problems or difficulties with which they are concerned. A further function of the bureau will be to collect and make available much practical and hitherto unpublished material obtained from various sources throughout the country.

General.

There has been some unavoidable sickness amongst the staff which has necessarily slowed up progress, at least for the time being, on certain lines of work.

Owing to pressure of work several members of the staff have found it impossible to take full advantage of the local leave period which is granted.

Major B. J. Eaton went on long leave in June of this year.

The task of bringing the Institute to its present stage of development has been one of some magnitude. The work of the staff of the Institute through the difficult initial period is deserving of recognition and is recorded here with appreciation.

G. Bryce,

Director.

October, 1928.

STAFF DISTRIBUTION LIST.

1st November, 1928.

Date Assumed Duty.	Designation.	Name of Officer.
25/ 9/26	Director	... G. BRYCE, D.Sc. (Edin.)
	Botanical Division.	
1/ 6/27	Head of Division	... F. SUMMERS, D.S.O., M.C., B.A. (Cantab.), B.Sc. (Lond.), M.Sc. (L'pool).
1 11/27	Plant Breeder	... L. E. MORRIS, M.A. Dip. Agr. (Cantab.), B.Sc. (Lond.)
15/ 6/27	Plant Physiologist	... C. E. T. MANN, M.Sc. (Lond.)
15/ 6/27	Biochemist	... E. RHODES, Ph.D., M.Sc. (Leeds).
3/ 1/28	Technician	... H. GUNNERY.
1/ 1/28	Asst. Botanist	... K. N. KAIMAL, B.A. (Madras).
	Chemical Division.	
1/11/26	Head of Division	... B. J. EATON, O.B.E., F.I.C., F.C.S.
1/12/26	Chemist	... R. G. FULLERTON, M.A. (Hons.), B.Sc. (Aberd.)
	Colloid Chemist	... ———
	Pathological Division.	
15/ 6/27	Head of Division	... J. R. WEIR, B.A. (Indiana), Ph.D. (Munich).
1/11/26	Pathologist	... A. R. SANDERSON, F.L.S.
1/11/26	Pathologist	... H. SUTCLIFFE, A.R.C.S., F.L.S.
	Soils Division.	
1 6 27	Head of Division	... W. B. HAINES, D.Sc. (Lond.), F.Inst.P., F.R.Met.Soc., D.I.C.
15/ 6/27	Bacteriologist	... A. S. CORBET, Ph.D., B.Sc. (Lond.)
10/ 2/28	Soils Chemist	... C. F. FLINT, Ph.D., B.Sc. (Lond.), A.I.C., A.R.C.S.
	Physicist	... ———
	Field Officers.	
15/ 6/27	Field Officers	... F. BILLINGTON, M.A. Dip. Agr. (Cantab.)
15/ 6/27		... N. C. JENKINS, M.A. Dip. Agr. (Cantab.)
15/ 6/27		... F. BEELEY, B.Sc. (Leeds)
	Experiment Station.	
9/12/27	Manager	... D. S. GARDNER.
	Information Bureau.	
1 11/28	Librarian	... P. S. HUDSON, B.Sc. (Leeds).
	Office.	
1/ 4/28	Secretary	... V. L. CACHEMAILLE, F.I.A.N.Z.
1/ 2/27	Curator	... T. O. MOORHOUSE.

SUMMARY OF WORK.

Botanical Division.

Up to 30th September, 1928.

1. Investigation of Variation in Hevea Brasiliensis.

By means of biometrical methods indexes have been determined which enable the identification and discrimination of various types of Hevea differing in yielding capacity to be carried out. These indexes have been worked out both for leaf and seeds, and have actually been applied successfully in the sorting out of clones which had been mixed in planting.

In this connection a collection has been made for the purposes of study of material from Java, Sumatra, Ceylon and Malaya. The latter includes seedlings from the earliest trees in Malaya, i.e., from Kuala Kangsar Residency and other sources.

The process of pollination of Hevea has been followed as far as possible and a study of its insect visitors made. This work is of the greatest importance in connection with the establishment of isolated seed gardens. In spite of the fact that insects have been observed frequently visiting the male flowers and removing pollen in quantity, not one instance has yet been observed of an insect visiting the female. The actual process, therefore, has not yet been observed.

An attempt has been made to develop a suitable technique for cross-fertilising Hevea in order to increase the degree of possible success. It has, as a result, been possible to make crosses between several pairs of high yielding trees and a number of these seeds will be available for sowing this season. This is eminently satisfactory for a first season's work and much valuable information has been gained on the self-sterility of certain clones.

II. Latex Studies.

So far it has only been possible to work out a method for the study of particle size in different types of Hevea with a view to using this as a diagnostic character. A collection of preparations has been accumulated for study.

III. Selection of High Yielding Types.

A collection of pedigree material has been formed for planting out shortly on the Experiment Station. These include second generation progeny of the well-known tree Heneratgoda No. 2 from Ceylon, and seedlings from the Tjikadoe seed garden of the Anglo-Dutch Company of Java. Seeds from high yielding clones investigated by the Division have also been secured.

IV. Vegetative Propagation of Hevea.

A standard manual entitled "The Budding of Hevea in Modern Plantation Practice" has been written incorporating all the most recent advances and the best advisory measures. Assistance has been given to upwards of 60 estates in carrying out their budding programmes and experimental work has been carried out on several estates. The result has been to obtain much closer knowledge of the technique, the most suitable season for carrying out the operation, the effect of the condition of the stock and the proper after-treatment of the young buddings.

In the laboratory an anatomical and histological study of the process of union has been carried out and has given much useful information, affording a better understanding of the principles underlying the method.

V. General.

A large number of advisory questions on cover plants, tapping methods, seed selection, planting methods and bark examination methods has been answered, and estates have been visited in every State of the Peninsula except Trengganu.

F. Summers,

Head of Botanical Division.

15th October, 1928.

SUMMARY OF WORK.

Chemical Division.

Up to 30th September, 1928.

Advisory.

Since its inception this Division has had to give a great deal of attention to advisory work on estate practice in the preparation of raw rubber for the market. This advisory work has taken the

form of letters sent to estates, lectures delivered from time to time to Planting Associations, and reports on samples of raw rubber and chemicals received for analysis. We have been concerned with the maintenance of a high standard and uniformity in the quality of plantation rubber exported from this country and in the production of a raw rubber free from those defects to which exception is taken by the market. We have given much of our time to a study of practical questions relating to the development of moulds in smoked sheet rubber and have established the practice of preventive measures the adoption of which on the majority of estates has given very satisfactory results. The technique involves the use of para-nitrophenol as an antiseptic. In connection with the preparation of smoked sheet advice on methods for the prevention of other defects such as bubbles, "rust", surface oxidation marks, tackiness, and surface glossines has been communicated by letter in reply to enquiries received, while to a less extent the advisory work has dealt with defects in crepe rubber among the most important of which are "spot" disease, non-uniformity of colour and/or texture, and tackiness. In the Laboratory a large number of routine analyses were carried out on behalf of estates of samples of acid coagulants, of latex, and of water used for factory purposes.

Organisation.

The new Laboratory is now fully equipped. Machinery for experimental work on the production of raw and of vulcanised rubber has been installed in the factory and an experimenal smoke-house and drying shed have been erected.

Experimental.

Since June 1927 the following investigations have been carried out to completion on questions of immediate practical importance.

(a) Methods for the prevention of the development of moulds in smoked sheet rubber.

(b) The difference between the dry rubber content of latex harvested under a system of "deep" tapping and of "shallow" tapping respectively.

(c) Factors influencing the appearance of "white streak" in smoked sheet rubber.

(d) The identification of the naturally occurring yellow pigment in latex.

Numbers (a) and (b) each extended over a period of six months while (c) and (d) each occupied about three months.

Publications.

The Institute's Planting Manual No. 1, entitled "Guide to the Preparation of Rubber" was compiled by the Head of this Division and has now been published.

A Planting Manual written in the Chinese language on the preparation of raw rubber for the benefit of Asiatic producers has been compiled and will shortly be published.

R. G. Fullerton,

Acting Head of the Chemical Division.

15th October, 1928.

SUMMARY OF WORK.

Pathological Division.

Up to the 30th September, 1928.

The work of the Pathological Division during the past year has followed closely the original plan of research as laid down by the Head of the Division. Certain emergency work has arisen which, although important in itself, has taken time from the major problems.

Much time has been given to advisory work. Over 610 letters have been written to estate managers. To date 140 estates have been visited. Eight lectures have been delivered by the Head of the Division. The work has been presented at three different places in the form of exhibits. A large number of planters have been in conference in the Division on estate problems. Much pathological material has been sent in for diagnosis and has been reported on. All this work is important in that it brings the planter and the investigator in closer contact.

Practical considerations of the relation of disease to planting methods and estate management, in which root disease problems

are the most important, have been followed very closely. Some twelve field experimental plots ranging in size from 1 to 100 acres and covering practically all the conditions under which disease factors are prominent are being established at the Experiment Station. In addition co-operative experiments on root disease problems are being set up on a near-by estate which have to do with gaining a more profound knowledge on the efficiency of the fungicidal value of lime, the influence of cover crops on root disease and general studies for the purpose of obtaining data on estate practices now in vogue for which additional experimental evidence is desired. Several important new facts bearing on the identity of host relationships, means and conditions of spread of the fungi responsible for root decay have been worked out. It is the hope that standard practices in disease control may be instituted throughout Malaya.

Rhizoctonia bataticola, for which much is claimed in Ceylon as a first cause of root disease of all plants has been found in the soil of Malaya. The results of a study on this fungus so far fail to indicate for it a primary parasitic action on rubber under normal conditions of growth.

Hevea seedlings in nurseries have been quite severely attacked in several regions during the year. The identity of the causal organisms was determined. Secondary leaf-fall in Malaya so far as investigated is found to be primarily due to mites with no indication of epidemic tendencies. Preparations are being made to give demonstrations to planters of the most modern technique of dusting and spraying, and to combat insect and fungus disease at the Experiment Station of the Institute.

Recent investigations on diseases of the tapping panel disclose certain phases of the condition known as Mouldy Rot which have not heretofore been sufficiently emphasised. The studies on fungicides and disinfectants are developing a new knowledge bearing on penetration and general efficiency, the object being to standardise estate practice by devising a limited number of fungicides that are cheap, effective and readily available.

The failure of certain cover crops under rubber has resulted in the discovery that in some cases at least the plants are parasitized by soil fungi. The causal organisms have been isolated, studied, and a preliminary paper prepared for publication. Immunity in cover crops is being sought through a comparative study of the susceptibility of a large number of species in relation to certain disease factors. The planting scheme of the Division now under

way at the Institute's Experimental Station provides for a comprehensive study of the diseases of cover crops and the relation of the crops themselves to root diseases of rubber.

Debility diseases in mature rubber have received attention in many parts of the Peninsula. It would appear from the studies so far that decline in vigour may be due to a variety of causes, rarely specific and mostly indirect, having nothing to do with primary parasitic action. A report was prepared on the subject covering a certain region and was quoted in the report of the Chief Agricultural Officer.

A visit to the rubber growing regions of Sumatra afforded an opportunity for a study of estate practice in those regions. The preparation of a manual of diseases, both in the native vernacular and in Chinese, and a larger work for the European planter are activities that continue to receive attention.

J. R. Weir,

Head of Pathological Division.

19th October, 1928.

SUMMARY OF WORK.

Soils Division.

Up to the 30th September, 1928.

To begin with it may be pointed out that, corresponding to the sinking of capital expenditure at the start, a great deal of time and energy have been expended in preparatory and non-productive work concerning organisation, training, building and equipment.

The work of the Division may conveniently be considered under the heads: Advisory, Meteorological, Field Work and Laboratory Work.

Advisory.

A great part of the time has naturally been given to answering enquiries and establishing the necessary close relationship between the Institute and the planter. Lectures have averaged one per month and visits over one per week distributed over the whole

peninsula. The volume of correspondence has been proportionately heavy. From the point of view of progress for the Institute this activity has ultimated in a large number of experiments laid down on various soils, from which is accruing much-needed information on the effect of manuring, cultivation and cover crops on yield, growth and bark renewal. It has also given the staff clear ideas on the more pressing problems of the industry.

Over 80 soil samples have been analysed in the course of advisory work, but it is entailing great effort to catch up for the time during which this type of work was not possible.

Meteorological.

The meteorological records have two aspects, firstly the taking of detailed records which would otherwise not be available, for research into the relationship of climate to rubber cultivation, and secondly the more usual type of daily record for the common use of the whole Institute. In connection with the latter we have received the assistance of the Government Meteorologist with whom we are co-operating.

A Callendar Recorder has been installed since the beginning of the year by means of which a daily chart is recorded of solar radiation. Also weekly charts are obtained of humidity, barometric pressure and soil temperature (two depths). In connection with rainfall a gauge has been specially constructed so that adequate analyses can be made of the rate of rainfall. No standard pattern is capable of doing this for tropical rainfall, so that details are being worked out almost for the first time. The accumulation of records since the beginning of the year on all those points has already put a lot of new information in our possession.

Soil temperature records have already been fully recorded under jungle and under fallow exposed conditions. These will be extended to soil under cover crops and under clean-weeded mature rubber. Part of this work has been done in conjunction with the Forest Department.

Field Work.

Field work has entailed a large amount of visiting as stated above. In addition we have assisted in planning or in examining data from upwards of 20 field experiments on different estates. Most of these concern the direct effect of manuring upon latex

yield, but measurements of bark renewal and growth are also being made and reported.

On our own experiment station plans have been made for laying down a manuring experiment upon the most approved modern lines and the first treatment of the plots has been carried out. Close observational work is being planned on the plots to measure the effect of manures on rate of growth of young rubber. The soil samples for a survey along the whole length of the North and South rentice have been assembled.

Laboratory Work.

One member of the staff is engaged upon certain points regarding the bacteriological conditions in local soils, and has completed a considerable series of measurements upon two typical soils. One matter of immediate concern is the growing of leguminous covers and it is more than probable that inoculation methods will help in many cases. Several cultured experiments are in progress to test this point. There is the further problem of humus decay and a type of sterility which seems to be due to the intense degree of insolation.

Another member of the staff has been engaged in organising the routine analysis work (soils and fertilisers) and in training assistants for this work. Very recently a large number of new methods have been advocated, many of which are very simple and time-saving compared to older methods. A good deal of attention is being given to selecting the best among these for adoption by the Division. Emphasis is being laid upon physical tests, since such properties seem to have particular significance for good rubber soils. Particular attention has been given to those properties concerned with drainage problems and the prevention of erosion.

Plans are ready for starting pure culture work in sand on the nutrition of young rubber, and we expect to get this experiment going with seed of the present season.

W. B. Haines,

Head of Soils Division.

15th October, 1928.

SUMMARY OF VISITS PAID TO ESTATES.

NOVEMBER 1926—OCTOBER 1928.

		No. of estates visited.	No. of visits paid.
Director	...	14	14
Botanical Division	...	60	92
Chemical Division	...	26	27
Pathological Division	...	57	62
Soils Division	...	56	67
Total	...	213	262

ANALYSIS OF CORRESPONDENCE.

Estate Enquiries and Planting Problems Only.

November 1926—October 1928.

Subjects.	No. of letters received.
Anti-Oxidants of Latex	4
Anti-Coagulants of Latex	27
Machinery of Rubber Manufacturue	7
Vulcanisation of Rubber	6
Crepe	76
Slab Rubber	9
Crepe Lower Grades	17
Coagulants	41
Rubber Preparation	3
Latex	83
Latex Preservation	13
Latex Concentration	4
Latex—Instruments for Determining Dry Rubber Content	54
Coagulating Tanks and Pans	6
Sole Crepe	40
Smoked Sheet	463
Smoke Houses	10
Air-dried Sheet	5
Water	27
Abnormal Growths on Hevea	1
Injury by External Agents	238
Fungus Diseases of Rubber	248
Brown Bast	155
Cover Plants	73
Epiphytes of Rubber	5
Fungicides	10
Tree Operations	12
Die-back	15
Re-planting	7
Seed-bed and Nursery Diseases	7
Thinning	3
Weed Suppression	2
Bud-graft Diseases	10
Cultivation	10
Manuring	329
Soil Conservation	1
Drainage	33
Budding—Estate Enquiries	285
Estate Isolation Areas	21
Earliest Introduced Rubber Trees	12
Tapping	23
Seed Selection	1
Catch Crops	2
Fertilizers	10
Soil Samples	74
Water Supply	4
Electroculture	3
Statistics of Yield	4
Experimental Areas of Mature Rubber	1
Correspondence with Individuals	49
Latex Vessel Rings	16
Planting	8
Budding—General	44
Fertilisation of Hevea	2
Total	2,623

STATISTICS OF LECTURES DELIVERED.

February 1927 to October 1928.

ORGANISATIONS	Director		Botanical Division		Chemical Division		Pathological Division		Soils Division	
	1927	1928	1927	1928	1927	1928	1927	1928	1927	1928
American Visitors					1					
Batang Padang District Planters' Association ...			1				1			
Batang Padang Branch I. S. P.						1				
Central Perak Planters' Association				1	1					
Johore Planters' Association			1							1
Klang Branch I. S. P.				1				1	1	
Kajang Branch I. S. P.			1					1		1
Kajang District Planters' Association	1									
Kedah Planters' Association			1						1	
Kelantan Planters' Association		1		1						
Kuala Selangor Branch I. S. P.								1		
Malacca Planters' Association		1	1	1		1			1	
Muar Planters' Association			1						1	
Muar Civil Service Club								1		
Nilai Branch I. S. P.			1				1			
Penang I. S. P. Conference			1						1	
Port Dickson I. S. P. Conference				1				1		2
Province Wellesley, I. S. P.				1						1
Sepang Club										1
Sitiawan Branch I. S. P.					1					
Taiping Branch I. S. P.				1						
Tanjong Malim Branch I. S. P.						1				1
Teluk Anson Branch I. S. P.				1	1			1		
Total ...	1	2	8	8	4	3	2	6	5	7

Total = 46

SOME CONSIDERATIONS ON SILT-PITTING.*

By W. B. HAINES.

Considered as a planting topic the subject of silt pitting is marked by the number of points it presents which have not yet got beyond the controversial stage. This is but the reflection of the fact that it is a comparatively short time since soil conservation work of this kind was introduced into rubber estate practice. So many variations are presented by the different soils and situations and by the different ways in which silt-pitting may be devised, that it is little wonder that a settled practice does not immediately emerge. Even the limits under which the different schemes may be regarded as applicable have never been properly defined. Practices which have been found to work well under a given set of conditions may want examination and modification before equally good results may be expected under changed conditions. It is the purpose of this paper to deal with some of the more fundamental points which must be considered in evolving from the stage of conflicting opinion towards that of a standard practice, though much remains to be done before the details of such standards can be firmly laid down.

In some respects the term "silt-pit" as applied to most of the soil conservation work to-day is not too well chosen, although it has probably come to stay. It is apt to carry with it the idea of silt-collecting pits rather than that of silt-prevention pits. Silt being the product of soil erosion it is plain that an ideal system for preventing erosion will put silt out of the question. It is certainly the less of two evils to collect silt rather than to lose it, but it must be quite clear that to prevent any silt formation at all is the vital aim of all remedial measures.

This criticism does not bear the same weight in cases where the pitting may be regarded as a temporary expedient, and this question as to the permanency of the pits is one that we must deal with at the outset. The most natural way in which wash can be prevented is by the growth of low-growing cover. Where such is feasible silt-pitting may be introduced as a merely temporary measure to protect freshly cleared land until a cover can be established. In such a case it is not objectionable if the pits do fill up

*This paper was given as a lecture to the Annual Conference of the Incorporated Society of Planters, July 30, 1928.

in a short time. But in the main we are speaking of systems which it is desired to maintain permanently. A good stand of rubber may be expected ultimately to carry such a heavy canopy of leaves that an adequate ground cover is likely to prove an impossibility on account of shading. In such a case earthworks must be relied on to stop wash, since a tree canopy is not of such a type as to simulate the protective action of a ground cover. We may say then that, although the ideal prevention of soil erosion is provided by the natural conditions of a ground cover, yet this must often be reinforced and sometimes replaced by a system of silt pits under the conditions which apply to rubber plantations.

The soil erosion with which we are dealing is that produced by excessive rainfall—excessive in its rate of fall rather than in total quantity over a long period of time. The eroding action is of two distinct kinds, one a disintegration produced by shear impact of large drops and the other and most important the wash produced by cumulative surface-flow of water. The first action is most noticeable where soil has been loosened, as on a bund, and gives rise to those little pillars of soil which one so often sees. Fitting exactly on the top of each one will be found a stick, a leaf or some small object which has protected the soil immediately beneath it, while all round the soil has been cut away in the vertical line of impact of the falling drops. In other circumstances, as on a level clay soil, an opposite effect may be produced, the falling drops in that case puddling the soil surface by their impact and producing a state of unhealthy consolidation, or deflocculation as it is called.

The most important action that we have to combat, then, is the surface flow produced by rain falling at a rate in excess of that at which the soil can absorb it. The pit is a simple expedient to increase effectively this capacity of the soil to take up the water. Water movements in soil which govern the question of absorption take place as the result of a difference in pressure between two locations, and such differences may result from two quite distinct causes. In the first place there is the universal hydro-static head produced by gravitation and secondly there is the effect of capillary suction. One tends to increase the pressure while the other decreases it, but both cause movement. In certain cases the capillary effect may be the largest factor producing water movement, and it may also act either in conjunction with or against the gravitational effect according to circumstances. Consider the course of events when rain falls upon a dry soil surface. At first it is quickly absorbed, mainly by capillary attraction, since the capillary suction is generally high for dry soil. As the saturated surface layer extends, however, the water front reaches moister soil and the

capillary suction diminishes; also the resistance to water movement is proportional to the depth to be traversed, so that for two reasons the rate of water absorption rapidly diminishes as the depth of penetration increases. In addition to this there is a very important effect which comes in to bring water penetration to a standstill, and that is the trapping of air in the soil pores. It is self-evident that water can only enter the soil if the displaced air can escape, and this escape may be prevented if the rain is of such intensity as to saturate completely the surface layer of soil and leave no open pores. If the underlying layer contains much air, that is, is fairly dry, the water above sits on a pneumatic cushion, as it were, and cannot penetrate farther. In ordinary cultivation the practice of ridging helps to get over the difficulty, and in rubber estate practice there is little doubt that silt-pits also help by providing subterranean outlets for the displaced soil air. All such movements, of course, benefit the soil. These considerations apply to the rapidly changing conditions of a rain storm. The slow water movement which goes on by which the soil drains under gravity is of equal importance because it is incessant. The soil holds a certain proportion of water by capillarity and the rest tends to drain always lower at a rate depending upon the openness of the soil texture. This continued subterranean flow is well evidenced by the way our rivers continue to be fed even after rainless periods.

A large part of the rainfall in Malaya is of that intense type which no soil, however porous, can keep pace with by absorption. In Fig. 1 some of the rainfall records taken at the Rubber Research Institute are so presented as to show this characteristic. The values have been plotted to show the *rate* of rainfall at any given moment. Taking the curve in broken line we have an ordinary steady rain presented. The average rate of fall over several hours is about $\frac{1}{4}''$ per hour and the greatest intensity reached is about one inch per hour. The total is $1\frac{1}{2}''$ and the period would be reckoned an exceptionally heavy rain in the temperate zone. Yet the comparison with the curve in continuous line, which shows a more typical local downpour is very striking. The rain comes in bursts which reach an intensity of $6''$ per hour. The last burst would certainly fall upon a soil already saturated and it represents over an inch of rain deposited in fifteen minutes. This alone would be one hundred tons of water per acre to work havoc by surface flow unless silt-pit accommodation is provided for it.

The great secondary advantage of silt-pitting is that the moisture is conserved as well as the soil. The sites which stand in greatest need of the one, namely hilly land, are also in greatest need of the other, since on a hill the trees are much less likely to

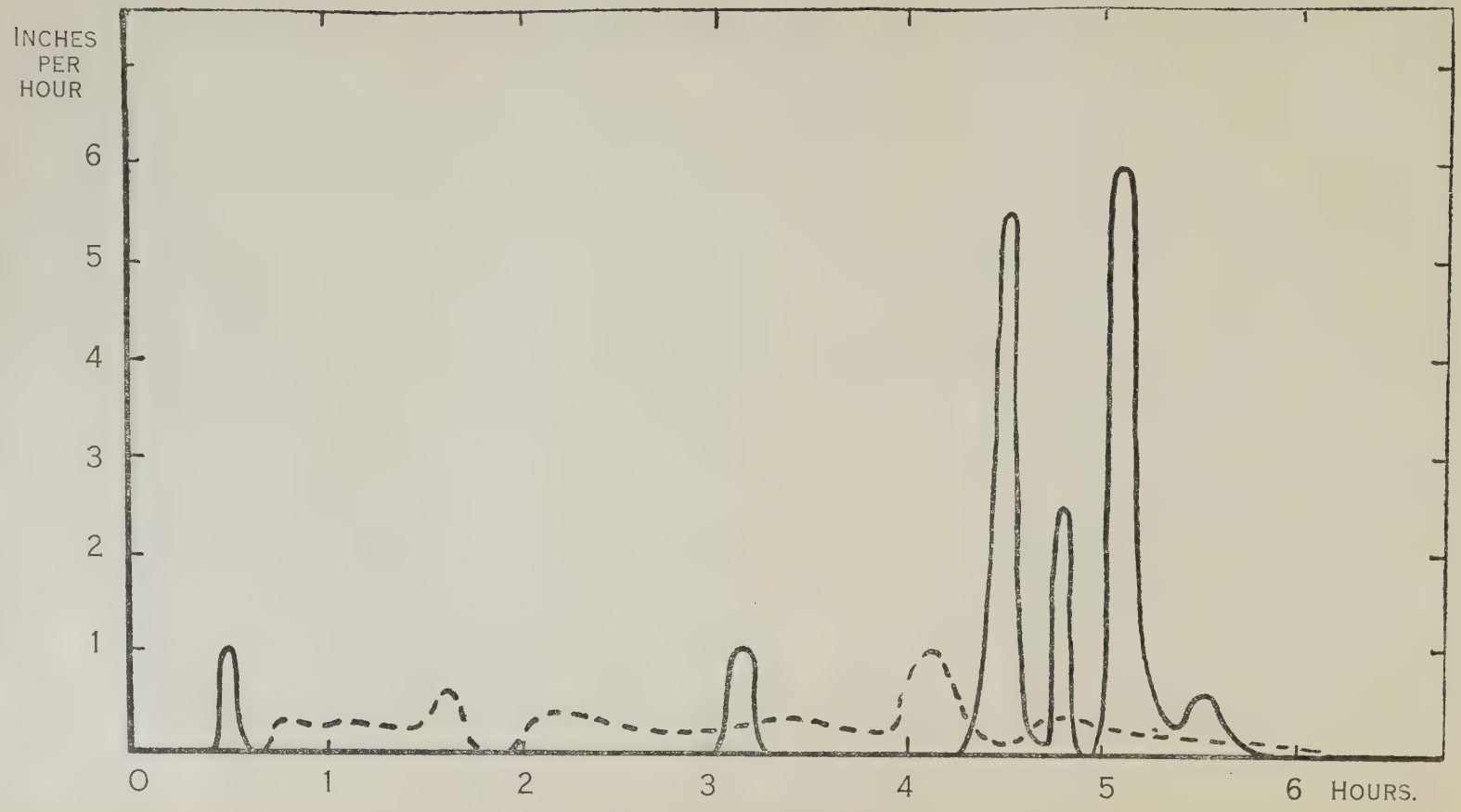

FIG. 1.

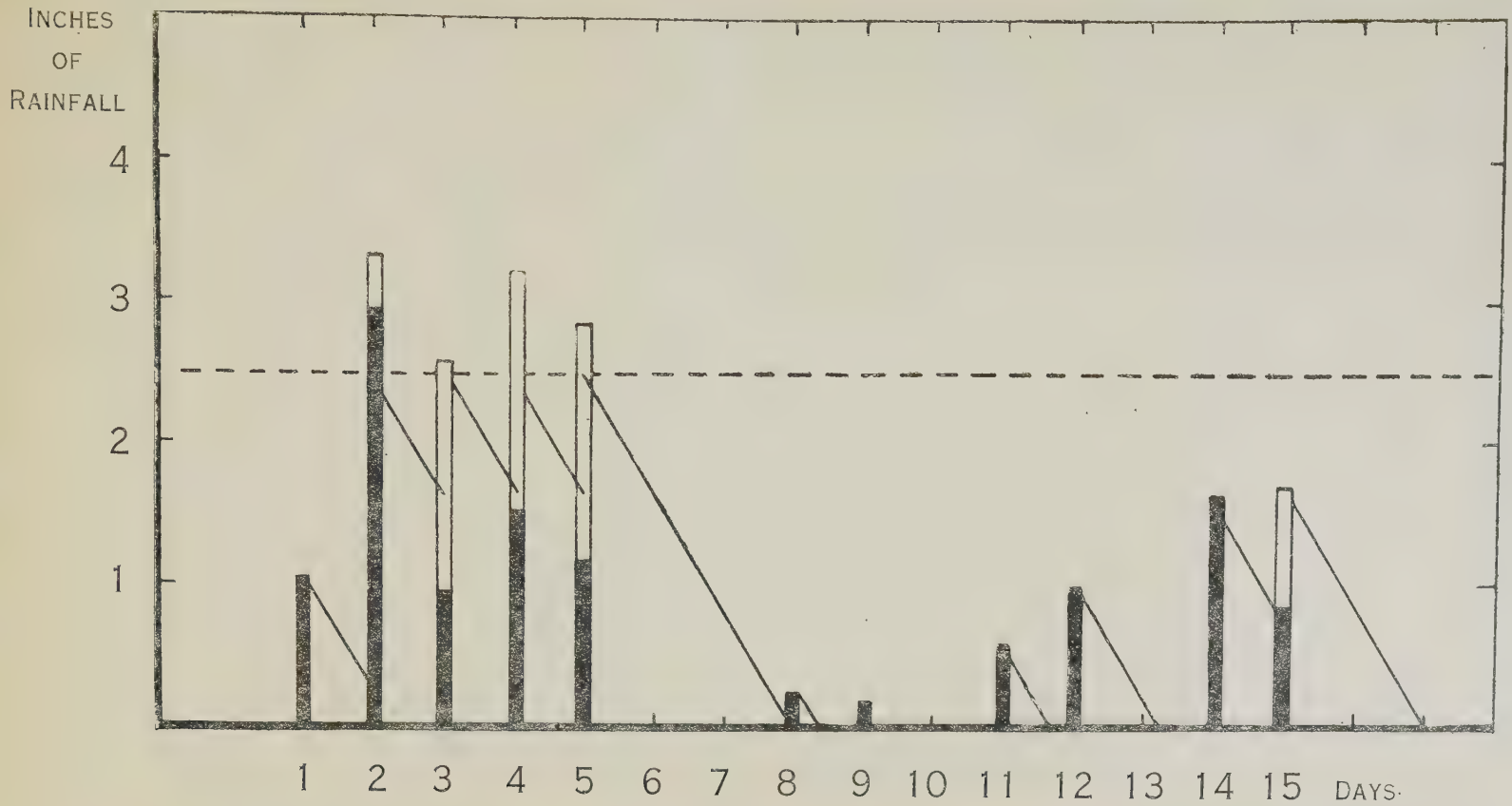

FIG. 2.

be within reach of permanent ground waters than on the flat. Silt-pitting causes much greater quantities of water to percolate naturally into the soil of a hillside. In this way the trees not only get a more adequate moisture supply, but they may get a more extended root range which is of the greatest value. This is analogous to the beneficial effects of drainage on flat land. Although in the one case we are draining water into the soil while in the other case we are draining it out, yet the effect of water movement and consequent aeration is the same in replacing stagnant conditions with healthy ones. It is sometimes assumed that aeration is effected merely because a hole is dug and the soil exposed to the air, but this is by no means the important aspect of the case. Indeed, it is important to remember that added exposure means added evaporation, which has its disadvantages under certain circumstances.

In making the calculations necessary for scheming a system of silt-pitting the most difficult point to deal with is to decide what quantity of excess rain is normally to be dealt with. The term normally is used because it is probably impossible or at least uneconomic to devise the system to meet the very exceptional cases of excessive and continuous rain.

The pits must have a capacity to hold the excess water of a normal rain with an additional reserve to cover the contingency of further rain falling before the pits have had time to empty. The last factor becomes so great on some heavy soils owing to the extreme slowness of percolation, that it sets a very serious limit to the utility of pits on such sites. Thus we require data both as regards rainfall and as regards soil permeability before we have a basis for laying down a sound scheme. One method of roughly examining the data is shown in Fig. 2. Along a line divided into intervals to represent days blocked in, columns are erected of heights to correspond to each days rain. The case shown is the most rainy period during a year's records at Kuala Lumpur. For the purpose of the examination we will suppose that it is proposed to dig pits to have a capacity of $2\frac{1}{2}$ inches rain, which would correspond to a system of pits 24″ x 24″ section placed continuously on contours about 19 ft. apart. We will further suppose that percolation out of the pits is at the rate of 1″ per day, so that full pits would take $2\frac{1}{2}$ days to empty. Most soils on hill sites would take less time than this, but it must be remembered that the rate will fluctuate greatly according to the degree of soil and subsoil saturation. Imagine now that the height of the columns represents the degree to which the pits are filled each day. Starting at the first day we allow a small proportion of rain taken up by the soil and draw a sloping

line at the requisite angle to show the rate at which the pit will empty. The amount cut off by this line on the next column may be taken as the amount of water left in the pit when the second day's rain falls and the column is extended by this amount. This procedure is carried on, so giving a rough idea of the state of the pits at any time during the rainy period. When the extended column rises higher than $2\frac{1}{2}$ inches this indicates overflow and consequent damage due to inadequacy of pits. It will be seen that this occurs on the second day and the three subsequent days, the total wash corresponding to about 2 inches of rain. It is easily seen, however, that if the pit capacity were increased to 3 inches the wash would be stopped. It would also be considerably reduced if the percolation rate into the soil could be taken as more rapid. By means of such diagrams based on their own material estates may usefully examine the adequacy of any proposed scheme. The records for a complete year at Kuala Lumpur were examined in the way described and there were four occasions when the conditions assumed would have proved inadequate and led to overflow. Three of these would have been prevented by an increase of capacity from $2\frac{1}{2}''$ to $3''$ of rain, but the fourth would have required pits of $4''$ capacity. It should not be difficult to judge the point at which the risk of overflow is so small that it is economic to neglect it.

The calculation of capacity is very easily made on a cross-sectional basis if the pits are placed continuously on the contour. By way of example it is easy to see that a pit $2'$ wide by $1\frac{1}{2}'$ deep will have a cross section equal to that of $2''$ of rain over 18 ft. of ground (432 sq. inches in each case). Hence continuous lines of pits of those dimensions placed at 18 ft. intervals would hold up $2''$ of excess rain. It is easy to adapt the calculation to the planting distances and other factors affecting a particular case. On the same basis the capacity of a terrace may be estimated in terms of its width and inward slope, remembering that in this case the cross section is triangular instead of rectangular. When the line of pits is not continuous the calculations must be based upon cubic contents. As already stated a distinct limit is set to the usefulness of silt-pitting if the pits do not empty themselves by natural percolation in a reasonable length of time. Fortunately it is unusual to find heavy impervious soils on the hill sites which stand most in need of silt-pitting. Under ordinary circumstances pits should drain clear in two or three days. If they do not normally dry up between one period of rain and the next the sodden conditions themselves produce an impervious state. For the action of the surface soil of the pit is that of a filter and its pores tend to become clogged with a fine slime extracted from the water. This clogged state of the lining of the pit will become permanent unless inter-

vening dry conditions occur. The advantage of dry conditions is that this lining shrinks and cracks and this helps very much to keep the pit functioning properly.

Apart from the uselessness of water lying stagnating in the pits there is the positive objection on health grounds of providing such breeding places for mosquitoes. It is clear that a pit which is always half-full of water has no distinct advantage over one that is half full of soil, so that it can be laid down that, at any rate in areas where health considerations are important, sluggish silt pits should be filled in until their capacity is such that they empty themselves in a safe period and modified methods adopted. The safe period from this point of view might be set at a week. Hard and fast rules are hard to lay down because of the varied distribution of the rainfall, but the man on the spot can easily judge from frequent observation how far his pits are proving a health menace and deal with them accordingly. The type of diagram already discussed can be used to examine the periods during which the pits are never empty and the possibility noted of these being longer than the safe period. During the year examined the analysis indicated two periods only during which pits would hold standing water for longer periods than a week and these were very little in excess. During very wet periods water lies about under any conditions, so that the pits do not constitute a new problem though they may much aggravate an old one. Oiling may be resorted to if necessary, but this does not constitute a full solution for the whole problem owing to the great number of pits and the big chance of overlooking some of them. Vigilance is the first requirement, and it may call to its aid both oiling and the partial filling in of pits.

While on the subject of health there is another aspect of the matter which has been raised. The increased percolation into the hill sides produced by silt pitting may cause unexpected seepage at the base, and so provide new breeding places for mosquitoes. Since forewarned is forearmed, this need be no menace if provided for by drainage. It may simply be looked upon as a possible slight increase in the total cost of carrying out the complete scheme. Seepage appearing sporadically in the neighbourhood of particular pits is in the same class as pits which retain water too long.

The next point which comes up for consideration is that of pit maintenance. Where the work of the pits is strongly reinforced by a ground cover the question is not urgent, but it becomes so in many cases where the system must be regarded as permanent.

It has already been emphasised that a properly devised system should not silt up quickly, but the action is not always entirely avoidable. The advice has often been given to let one system of pits fill up and then cut others in fresh situations. The main reason for this seems to be to avoid disturbing the feeding roots which come to the old pit on account of the richer, moister and better aerated soil conditions there. I cannot find myself in agreement with this course of action in rubber. The two main objections are, first, that a considerable period of inefficiency must intervene when the old system is disappearing and the new system is not yet dug and, second, that by the time that several new sites have been dug over a severe breaking up of the main root system of the trees must be effected. A regular plan of cleaning pits, on the other hand, maintains them at their best and involves only a disturbance of young feeding rootlets. It also tends to obviate that clogging up of the pit already referred to. The decaying material which is apt to collect at the bottom of a pit is not lost as food for the tree just because it is removed and spread on the surface.

Probably the most debated point of any that comes within my province is the question as to which side of a silt pit the spoil should be placed. A bund immediately above a pit stops the surface water from finding its way in naturally, while when the bund is placed below it reinforces the pit both as to strength and capacity. Hence the common practice of placing the bund below has common sense to commend it. But there are further points to be considered. It is equally good sense to contend that, since silt pitting has as its main object the combating of the natural tendency of the soil to reach the bottom of the slope, the spoil should therefore be thrown out up the slope. This applies particularly to the spoil obtained from cleaning. But the main advantage which advocates of this method have in view is that of using the bund itself to form a water catchment. Indeed some people so emphasise this aspect as to look upon the pit merely as the best means of winning the soil to form a bund. This is in the generality of cases an exaggerated view to take. A bund holds up the water in a large shallow puddle. This certainly gives the maximum surface for the water to drain into the soil and to that extent disposes of it quickly and naturally. When the soil is pervious enough to do this there can be no objection. But it must be very strongly emphasised that on the heavier types of soil when the puddles stand about for some time they produce a very deleterious effect on the physical conditions of the soil surface. The ideal to aim at is to utilise both bund and pit to their fullest extent, which means that they must be separated in some way or another. That seems to be the central fact of the case with its accompanying increase in

the expense. There are many ways of planning the utilisation of the spoil in the form of a separate bund. The best way is a continuous bund on the contour between the rows of pits, or where this is not possible separate portions may be given a horse-shoe form, the ends carried up and away from the pit below. In all cases everything must be done to avoid standing puddles round the base of the trees.

The secondary advantage of placing the bund on the upward side of the pit is that on steeper slopes an ultimate terrace formation may be attained, or it may aid when a combination of pit and terraces is being cut*. Such cases require considerable care in consolidating the bund against attrition and may depend for success on direct methods of consolidation. Such cases are in a class to be considered on their individual merits, since any method which begins with one form with the intention of evolving into another brings in too many local factors for successful generalising.

Many different forms can be devised for the cutting of silt-pits, each of which may have its special advantages. No doubt the narrow ditch form along a contour is the best. But owing to the fact that pitting is always done in separated sections, there is a very large number of ways in which they may be disposed. Where planting is not on the contour and pits are dug between each group of trees, there is a natural tendency to an echelon formation such as is required to break up surface flow. The narrow pit gives the larger surface for percolation and also the least possibility of losses by evaporation. The depth of the pit is quite a local matter, depending upon subsoil permeability. Frequently a much less pervious condition of soil exists at the depth of 18″ or 24″, and there is not much advantage to be gained by cutting into this. If in special cases there is prospect of cutting through a stiff layer into a more pervious sub-stratum, this should be favourably considered.

The combination of some form of modified silt pit in conjunction with terracing on the steeper slopes has much to commend it. Terrace maintenance is improved and the functioning simplified, by shallow pits dug at the back, the spoil from which is dragged forward and spread on the edge. In this case surface water reaches the pit from both sides, since the terrace slopes inward. The capacity of the terrace to hold water is much increased in this way, and the tendency for water to lie in puddles is also diminished.

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*Compare the combination described by R. P. Hunter in "The Planter" for September 1928.

The main features which emerge from these considerations may be summed up as follows:

1. In the first place a low-growing ground cover must be looked upon as the main line of defence in regard to soil erosion. It protects the soil from direct impact of the rain as nothing else can do; increases the absorptive capacity of the soil while at the same time binding it together; and maintains healthy conditions in the soil surface.

2. Silt-pitting may be very useful in conjunction with a cover, in which case it may be either temporary or permanent and only in the last resort should it stand alone as the sole means of protection.

3. Unless the silt-pitting system is definitely intended only as a temporary measure it is best to maintain the original system by periodic cleaning.

4. Since it is very problematical whether a pit which retains water for a period of many days has any advantages, it is advisable for health reasons to fill up such pits till their capacity is reduced to the required extent.

5. Simple bunding at the side of the pit is best done on the downward side in most cases: but where the bund can be moved away from the pit a variety of improved arrangements can be made to utilise the catchment value of the bund.

PRELIMINARY STUDIES ON SOME DISEASES OF COVER CROPS UNDER RUBBER IN MALAYA.

By JAMES R. WEIR.

Introduction.

The failure of cover crops under rubber may be due to any one of a number of causes. For example the proper inter-changeable nodule bacteria may be absent from the soils. The growth of these organisms may be prevented or inhibited by the presence of some adverse soil condition which results in the production of plants of such lowered vitality that they become more than normally subject to disease organisms which may be present in the soil. Some recent pot culture with *Mimosa invisa* shows that when these plants are grown in a soil taken from a grass blukar* situation on which cattle commonly graze and where the common *Mimosa pudica* is present grows luxuriantly and develops root nodules in abundance. When a part of the same collection of seed was sown in the same soil sterilized or in a hard compact soil on which no vegetation was growing nodules were not produced. The plants were weak and yielded more rapidly to inoculations with *Pythium* and *Rhizoctonia* than the nodulated plants. Cover plants may fail through the absence of certain chemical elements necessary for their normal growth as in the case of alfalfa and clovers which require a certain amount of lime for their best development. The presence of chemical elements in excess of the plant tolerance limits may cause unhealthy conditions or complete failure. The use of varieties poorly adapted to existing soil or climatic conditions are to be considered. Finally the growing of covers without sufficient information with regard to their reaction to light and shade is to be mentioned.

Although failure of cover plants may not always be attributed to the presence of parasitic soil organisms, or of insects or diseases on the aerial parts, the final dissolution of the plants may result from their activities. In some cases parasitic organisms are of first importance. Observations and studies during the past 12 months show that the irregular development of certain cover plants

*Blukar = second growth jungle.

on some soils had to do with definite disease situations separate and apart from any of the other factors mentioned. It is proposed at this time to give a preliminary account of the diseases and causal organisms so far studied and discuss such means of control as may be considered practicable under the varying conditions.

Sclerotium Rolfsii Sacc.

Vigna oligosperma (*Dolichos Hosei*) is frequently observed to die out in more or less circular patches. The patches range in size from a few inches to several feet. Occasionally an entire planting of Vigna on rich humus soil turns brown.

Frequent cultural examination of diseased plants has demonstrated the presence of *Sclerotium Rolfsii* as the causal organism. This fungus is quite common in tropical and sub-tropical regions and frequently causes serious losses of herbaceous garden and field plants. It has been observed on various garden plants throughout Malaya. An examination of the stems and leaves of the affected plants will often reveal a fine cobweb like mycelium upon which are developed small bead-like sclerotia. These bodies resemble small smooth seeds and average about 1 to 2 millimetres in diameter. They are white when young and brown when mature. These sclerotia are richly charged with nutritive material and serve to tide the fungus over periods of drought or other adverse conditions. After periods of dry weather all evidence of fungal mycelia may disappear from the diseased plants but the sclerotia remain and later, on the return of moisture, develop mycelium. Exhaustion of the nutritive substratum will also cause the fungus to develop sclerotia. As rapidly as the cover plant is parasitized the sclerotia appear on the dead parts or if the mycelium on which they develop becomes exhausted through the failure of the vegetative parts of the fungus at the seat of infection, they may sometimes be developed on green parts of the plants. Sclerotial bodies as a rule are potential reserve structures for vegetative propagation. Those found on Vigna and other cover crops have not been observed to germinate in nature but in culture they germinate readily forming a white film of mycelium in abundance on which the sclerotia again develop.

The ability of sclerotia to resist drought is very marked. Sclerotia in cultures brought from America have recently been revived after being dry for over four years. Gadd and Bertus (2,4) report the revival of the sclerotia of *Rhizoctonia solani* after being kept dry for six years. The large sclerotia of certain species of

Poria, Polyporus, Lentinus and *Sparassis* may remain viable in the soil for long periods.

During wet weather the mycelium of *Sclerotium Rolfsii* chiefly grows on the surface of the plants. With a low atmospheric humidity the mycelium is more internal and may be observed on microscopical examination to ramify in the intercellular spaces but may also be intracellular. Not infrequently the affected areas resume growth and may become completely restored which is in the main a reaction to dry weather. The dry weather, especially if the plants are exposed to the sun, checks mycelial development on the serial parts of the plants. The fungus however is not killed. Although it is chiefly active above ground it also develops in the roots underground. This ectrotropic and endotropic habit of the fungus is important from the standpoint of control.

Vigna is very commonly affected. The disease is conspicuous on this plant because of its usual low growing habit and thinness of the cover formed. The fungus has also been found in nature on *Calopogonium mucunoides, Centrosema pubescens and Pueraria javanica.* Inoculation of sterilised soil in seven pots in which the sterilised seeds of *Centrosema plumieri, Mimosa invisa. Crotalaria anagyroides, C. usaramoensis, C. striata, Tephrosia candida* and *Leucaena glauca* (Lamtoro) were sown resulted in a general infection of the seedlings of all seven species. The controls remained free from the disease. The average of the interval between the time of inoculation and the death of the plants was 9 days. The seedlings were attacked as a rule at the surface of the ground and fell over while the tops were still green.

A test to determine the effect of soaking the seeds for 24 hours in water and weak acids on germination and subsequent attack by the fungus resulted in a 25% greater germination and a more rapid germination but the seedlings succumbed to the fungus at an earlier period of growth. This is attributed to the fact that the fungus vegetated more luxuriantly around the seed owing to the soft swollen condition of the seed coat.

Sclerotium Rolfsii has been observed to attack and kill the young hypocotyl of germinating rubber seeds, a condition that has been duplicated by inoculations.

Rhizoctonia solani Kuhn (Corticium vagum B. & C.)

In new plantings where a heavy growth of *Calopogonium* has become established it has been frequently noted that the latter turns

brown in patches and sinks below the general canopy of the cover. These brown patches occur more frequently during rainy weather. On the advent of dry weather the patches ceased to extend and would become obscured by the development of the surrounding plants. An examination of the stems in contact with the soil and of the roots showed that a fungus had penetrated and was apparently the cause of the death of the cortex. The parenchymatic tissues of the woody parts in microscopical preparations were found to be completely destroyed leaving the ligneous portions of the stem quite disassociated.

Growing over the affected parts of the plants above ground a fine fungous web was discernible. This mycelial web was made up of colourless yellowish brown septate hyphae averaging in diameter 7.5—12 microns. These hyphae frequently caused the leaves and stems to adhere. The general debris on the ground matted together by the hyphae formed a whitish layer. This layer in the main consisted of the same type of hyphae as those found on the aerial parts of the plants. On the green leaves and stems the web assumed a more flocculent and powdery appearance and showed on examination to consist of separate hyphae 6—12 microns in diameter with free standing basidia bearing usually four hyaline, oval, apiculate spores averaging 6.5—12 x 4—5.5 microns. On the diseased leaves and stems near the soil flocculent rounded hyphal masses were relatively abundant. These masses very readily formed sclerotia when the affected parts were held in a damp chamber. The sclerotia varied in size from a half to 4 or 5 millimetres and frequently coalesced to form larger structures. They were rounded or flattened and varied in colour from white to a deep chestnut or purplish brown. Under the lens the surface appeared smooth or irregularly pitted and covered with a hyphal investment, depending upon age and degree of moisture. The mature sclerotia were usually covered with droplets of a brown liquid during wet weather. Their structure was homogeneous being composed of fairly uniform cells without differentiation. The foregoing describes the main characters of the fungus as determined from study of field material.

The fungus was readily brought into pure culture from the hypha from the sclerotial masses and from the basidial spores. Each of these structures in culture produced the complete life history of the fungus. The study of cultures and subsequent inoculation work shows quite clearly that the fungus is identical with *Rhizoctonia solani*. It agrees in most particulars with authentic cultures from America and in the main essentials with a culture under the above name kindly sent to the writer by Mr. Murray of the Rubber Research Scheme in Ceylon. The Corticium stage

which has been surprisingly easy to produce both from field material in the laboratory and in pure culture agrees with authentic material in the writer's herbarium. The spores in the type material are slightly smaller and more conspicuously apiculate than in most British, American and African specimens.

Since the original collection on *Calopogonium* the fungus has been found causing brown patch effects in densely growing *Vigna*. These are the only two cover crop plants so far found infected by the writer under field conditions in Malaya. On the other hand it has been isolated from diseased lettuce. The fungus is widely distributed in temperate regions and the following brief review of some recent literature shows it to be common in tropical countries.

The "Mopo" disease of the Cinchona seed-beds in Java as originally reported by Moens and more definitely studied by Rant is referred to *Rhizoctonia solani* by Duggar (3), Gandrup (5) more recently reports the fungus in Java on *Vigna*. The writer obtained cultures of a fungus from diseased patches of *Vigna* and from a garden plant in Sumatra which later developed all the characteristics of *Rhizoctonia solani*. Gadd and Bertus (4) give a full description of the fungus and the disease on Vigna, paddy, groundnut, plantain and acacia in Ceylon. Shaw (12) reports the fungus in India. The fungus has been reported from South America and the West Indies. Reinking (8) describes a *Rhizoctonia* as causing a damping off of Citrus seedlings in the Philippines which appears to be the species under discussion. Schweizer (10) reports a single collection of a fungus on leaves and branches of closely planted Hevea in Java which he thinks is probably identical with or is a physiological form of *Rhizoctonia solani*. The fungus is strongly parasitic on *Vigna* but the local Rhizoctonia on *Vigna* did not grow well on Hevea. The writer's inoculation experiments with *R. solani* from *Vigna* show that it will parasitise young 5 days old Hevea seedlings causing a collar rot. Bertus (1) using a strain of *R. solani* causing a die-back of tea seedlings failed to infect seedlings of French beans, cotton, cowpea, groundnut and Lima bean. Similarly a strain from *Vigna* would not infect tea seedlings at the ground level. All this indicates considerable variation in the pathogenicity of *R. solani* from certain hosts when brought in contact with its usual hosts but as Bertus suggests it may represent a condition wherein the proper environment for infection was not provided.

The pathogenicity of the fungus from *Vigna* and *Calopogonium* has been fully established by inoculations from pure cultures on seedlings of *Vigna oligosperma*, *Calopogonium mucunoides*,

Tephrosia candida, Mimosa invisa and *Crotalaria striata* grown from sterilized seed in sterilized soil. Depending upon their age the seedlings either "damped off" at the ground level or were ringed at that point with the temporary formation of a callus just above the zone of infection. The latter remained alive for a short time but eventually succumbed to the fungus and remained standing. The early applications of a fungicide occasionally arrested the action of the fungus with the result that new roots were developed from the callus above and the plants survived. Covering the seedlings with a white damp cloth or with celluloid cylinders usually resulted in the fungus spreading over the stems and leaves of the plants after the manner of the fungus in nature.

No real distinctions in general behaviour or appearance have been noted between the culture obtained from *Vigna* and *Calopogonium* in Malaya, *Vigna* in Sumatra and the culture from *Vigna* in Ceylon. Evidently a single strain of the fungus is involved. Sowing of infected soil with sterilised seed of one species of cover in which another had succumbed to the disease with no marked difference in the behaviour of the fungus indicates the uniform character of the parasites from the different regions and substrata. Infections of cuttings of *Calopogonium* and *Vigna* were not successful until after the plants had formed a dense canopy over the tops of the pots simulating field conditions.

Pythium sp.

Centrosema pubescens on two widely separated estates previously cultivated has been found to be infected with a species of *Pythium*. The diseased plants grew on a soil rich in humus under shade and in a damp situation. The affected plants appeared in small isolated patches and were characterized by a lighter browning of the leaves than is usual with such infections. A very fine white web-like mycelium over-ran the plants causing the leaves to adhere and to remain suspended if detached from the stems. The older stems usually remained living, only the growing ends being parasitized. The mycelium also grew over the soil and the dead plant material beneath. A small quantity of the soil and dead and living leaves were introduced among young *Centrosema* plants in pots. Within ten days the plants were infected and were killed. Pure cultures were then made and tested on seedlings growing in sterilized soil. Out of fifty seedlings so treated 13 were infected at the ground level and died. The fungus was then tested on seedlings of *Indigofera endecaphylla* and *Vigna* with a like result.

The fungus appears to affect first the roots, especially the fine ones, then grows up around the stem and if the cover is dense the mycelium spreads over the stems and leaves. The infected rootlets when planted out yielded Pythium in all cases save one which produced a *Rhizoctonia* not previously mentioned in this paper. Infection is apparently greatly increased by excessive soil moisture. When infected plants in pots were kept well watered they damped off more rapidly than when dry. This agrees with the behaviour of the fungus in the open.

Further studies are being made of the causal organism and to determine the extent of the damage it may cause to cover crops. Its taxonomy is indefinite but its conidia and oospores seem to agree with the debaryanum type and with a form found on germinating rubber seeds. Sharples (11) and Thompson (13) report the isolation of a *Pythium* from Patch Canker and from late maturing rubber pods but it is stated that the fungus has not recently been noticed.

Control.

The measures that may be adopted to retard or control the three soil inhabiting fungi described above meets with difficulty in practice under field conditions. The measures available may be discussed under the headings of isolation, nurseries, soil sterilization, selection of site, combination planting, clean seed, rotation and immunity.

Isolation.—The first noticeable effect of the action of soil fungi as previously stated is the dying out of the cover in small patches. This may take place on any type of soil under wet weather conditions but is most noticeable on moist soil of high humus content.

As a first step when patch infections are noticed the patches may be isolated by a well defined trench. The fungi in the case of the herbaceous type of cover do not penetrate the soil to any great depth hence the trench need not be more than a foot and a half deep. If nothing more is done the trench should be kept free from the vines otherwise the fungus may cross to the other side. The trench should enclose a zone of healthy plants. A second step is to disinfect thoroughly the isolated patches with any of the soil fungicides named below. The infected plants should be removed from the area and burnt. Gadd & Bertus (4) in Ceylon in the case of *Rhizoctonia solani* recommended that the diseased plants should be collected in tins for removal in order to avoid dropping sclerotia on clean soil. They further recommend

that disease areas should be planted to *Indigofera endecaphylla* or *Centrosema pubescens* which they found during cultural experiments to be immune. On the other hand Schweizer (9) finds that the former is attacked by *Rhizoctonia solani* in Java. Gandrup (5) also in Java reports the immunity of *Centrosema* and recommends its use. The writer's experiments are not yet conclusive on this point and will be reported later. *Centrosema pubescens* has not been found infected in the field.

The difficulty sometimes experienced in establishing cover crops even on soils favourable to their development is due in part to faulty germination, damping off of the seedlings by soil fungi, failure of the seedlings to grow vigorously from the beginning and hence inability to withstand inhospitable conditions then present or which may appear later. These conditions may be in a large measure counteracted by establishing on soil free from infection, sizable nurseries from which vigorous seedlings or cuttings may be taken at any time. In view of the fact that the fungi described attack mature and vigorously growing plants with difficulty under ordinary conditions and are largely active during the wettest parts of the year, it is desirable that the planting on the permanent site be started off with well grown plants.

Soil Sterilization.—Most tropical soils contain a number of pathogenic fungi. The "damping off" of cover crop seedlings is a good example of their activities. In a small cover crop nursery this trouble can be prevented by soil sterilization. The two methods usually employed to sterilize soil are either to heat the soil directly or to use disinfectants. It appears desirable to describe these methods since they may be employed by the rubber planter for various purposes, for example to increase the percentage of germination of rubber seeds when planted in nurseries.

By heat.—Boiling water may be copiously poured or sprayed over the beds from an oil tin with fairly large perforations in the bottom. This will destroy most soil fungi. The top soil may be shovelled on to sheet or roofing iron elevated on iron posts about two feet from the ground under which a fire is built. The soil should be heated thoroughly for about one hour at a temperature just high enough so that the soil may not be picked up in the hand, say 70° to 100° C. The humus or organic material in the soil should not be burned. To make the control more efficient both the soil of the beds and the soil that has been heated may be sprayed with a two per cent formalin solution. The heated soil may then be returned to the beds. After two or three days the soil will be sufficiently serated for sowing the seeds.

The heating of the soil by the burning of new clearings is undoubtedly a factor in freeing the upper soil layer of many pathogenic fungi and reduces the incidence of disease appreciably. Covers established on soil that has been very thoroughly heated due to the burning of piled debris after the first broadcast burning are observed as a rule to be very luxurious and free from disease. Wood ashes and air-slaked lime are good disinfectants in the case of some soil fungi which work only in an acid soil and may be used to neutralise the after-effects of acid treatment. Duggar states that cultural studies have shown that *R. solani* is able to withstand a high percentage of alkalinity but believes the application of lime may restrain the activity of the fungus indirectly by raising the resistance of the host.

By disinfectants.—Patch infections of *Rhizoctonia solani* and *Sclerotium Rolfsii* under old rubber have been prevented from spreading by the direct application of one percent solution of copper sulphate. It may also be applied directly to the nursery beds. Experiments with pot cultures in which there was a high mortality among seedlings after artificially introducing *Rhizoctonia, Sclerotium* and *Pythium* proved that copper sulphate would completely prevent further damping off. Hartley's (6) extensive work on damping off of coniferous seedlings demonstrated the efficiency of commercial sulphuric acid (1-2 oz. per gallon of water at the rate of 1 quart per square foot before and after seeding) when applied to the seed-bed soil but it appears that some cover crops are not especially tolerant of acid treatment. The treatment however may hasten seed germination. It is well to state acid should be dissolved by pouring it into the water—never by the reverse process. Wooden or earthenware containers should be used for acid and copper sulphate and should be applied with sprinklers which have been coated inside with hot paraffin wax.

The formalin treatment of seed-bed soil is more efficient if the soil is afterwards covered with tarpaulin or sacking to prevent loss of the disinfectant by evaporation. Some three days after the removal of the covering the seed may be sown. Clean sand or coarsely powered charcoal spread on soil after seeding may be of value in counteracting fungi but these are amendments rather than disinfectants. If a strong solution of formalin is used it should be applied at least one week before seeding.

Experiments on seedlings in pots and on various garden flowers growing in beds infected with *Rhizoctonia, Pythium* and *Sclerotium* have demonstrated the efficiency of a standard normal solution of Semesan ($\frac{1}{3}$ oz. to 1 gall. of water, 0.25 per cent.) and

of Uspulun (1 oz. to 3 galls. water) in controlling damping off. Information concerning the nature, source and use of these fungicides may be had on application.

Selection of Site.—In field practice under shade where it is proposed to establish *Vigna* it is desirable to select the most favourable sites, viz. soil that is fertile, well drained and with an average supply of soil moisture. Planting may then be done during the dry periods of the year with greater assurance of success. The atmospheric moisture at the ground level which greatly influences the development of soil fungi will be less and the seedlings or cuttings will come away with greater freedom from infection. These areas may be carefully inspected, all infected patches, if any, eliminated and the areas used as a source of supply for other parts of the estate. When planting rooted plants or cuttings over-crowding should be avoided. Field observations and pot culture work demonstrate that the moisture factor is of great importance in relation to severity of attack. Park (7) especially calls attention to this fact by some recent work with *Rhizoctonia solani* on cotton seedlings.

The mortality among seedlings of cover crops especially on damp and poorly aerated soils may be expected to be high. A close examination of seedlings resulting from any of the practical methods of planting whether in drills, manured or unmanured, broadcasted, soaked or unsoaked always shows that a considerable number of the young plants have succumbed after a few days growth to parasitic fungi in the soil. Since the seedlings in the young stage are very liable to attack it is desirable to judge well the nature of the soil as regards drainage and soil moisture and as an alternative in some cases establish the cover by the use of cuttings or basket plants. The firm tissues of the latter at the surface of the ground where the fungus attack usually begins, prevents or retards infection until the cover is established.

Combination Planting:—*Calopogonium*, *Centrosema*, and *Vigna* when sown together may intensify infection on the most susceptible species but if the plants can be brought through the more susceptible early periods of growth it may be expected that the natural succession of the plants with increasing shade will work out successfully.

Clean seed:—In the case of the fungi concerned infected seed is unlikely if they are properly collected. Seed collected from heavily infected plants may contain sclerotia. Floating the seed of several species in water resulted in the discovery of a single

sclerotium. This, when tested in culture, proved to be *Sclerotium Rolfsii*. Soaking seed in acid or other liquids to promote rapid germination may not be desirable except for particular soil types. Seed disinfection may be practised where seed has been taken from diseased plants.

Rotation:—If it can be proven that certain species of cover plants are not susceptible to the soil fungi described in this paper crop rotation would be of considerable use. Soil fungi of the sclerotial type may survive in the absence of host plants for long periods of time. If susceptible plants are continuously grown the soil becomes infected and this results in greater damage during the wet months. The fact that cover plants are being extensively employed following a long period of clean weeding which tended to prevent the development of an infected soil makes it desirable to sustain the present favourable situation as much as possible by growing resistant species.

Immunity:—On those soils where cover crops have failed to develop owing to the presence of disease an intensive study of the diseased plants and conditions encountered is desirable. It is hoped that natural immunity may be fully established under field conditions for some of the best covers now in use in Malaya as has been indicated above. The cover crops used in different tropical countries are being assembled. It is possible that the variety and legume crop trials on diseased soil now being instituted may result in the discovery of other plants or varieties of plants now grown, which would not be affected by the factors enumerated.

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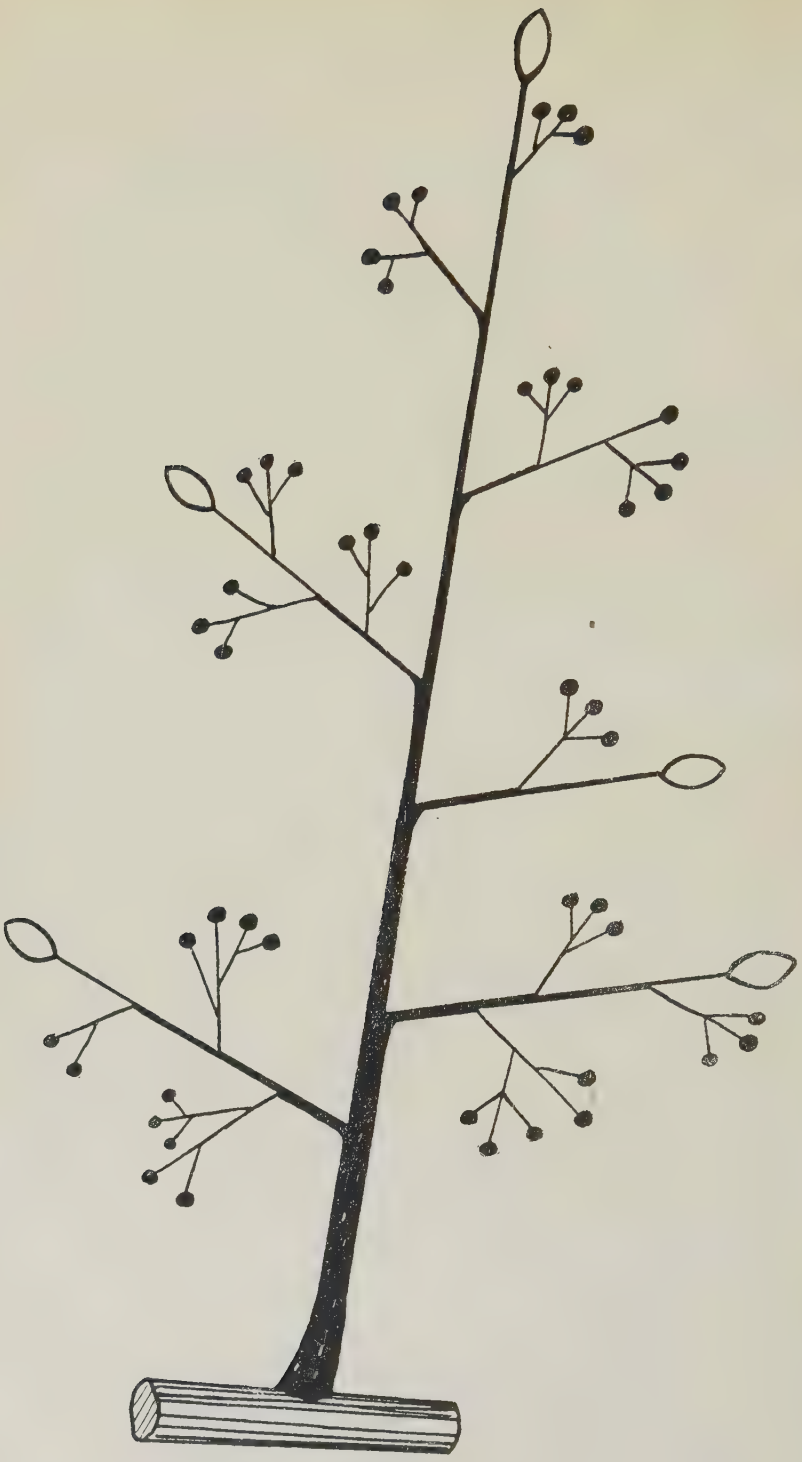

FEMALE FLOWERS *O* MALE FLOWERS ●

FIG. 1

FIELD OBSERVATIONS AND EXPERIMENTS

ON THE

POLLINATION OF HEVEA BRASILIENSIS.

By L. E. MORRIS.

1. Introduction.

In the improvement of a crop by selection or breeding the first steps to take are to study the natural methods of reproduction of the plant concerned and to find out how far the individuals already in our fields display the character we desire to intensify and preserve, so that the most suitable stock for selecting or breeding from can be chosen.

With Hevea we wish to grow trees that will yield large quantitites of rubber and also possess the advantageous characters of disease resistance, suitable tree shape and so on. It is well known that the bulk of the crop from any particular field comes from only a small proportion of the trees and it is from such high yielders that we must generally start in any attempts to improve the general standard of plantation rubber, whether by budding, seed selection, or the breeding of new and better types.

It is with the last of these methods that the present note is concerned.

2. The Structure of the Flower and the Development of the Bud.

During the flowering season the rubber tree produces masses of flowers, which are borne in bunches (inflorescences) towards the end of the leafy twigs where the new season's growth is starting. Each inflorescence is much branched and bears two kinds of flowers. The female flowers are situated at the ends of the central axis and of the main side branches, while the male flowers occur in much greater numbers on all the lesser shoots as indicated in the much simplified diagram—Figure 1. The flowers of both sexes are surrounded by a bell-shaped corolla of usually five yellowish petals. The female flowers can be distinguished not only by their terminal position but also by their greater size and by the small green button-like expansion at the base of the petals. When

the bud opens the round green ovary can be seen inside carrying on top three whitish lobes. These are known as the stigmas and form the receptive portion of the female sexual apparatus; Fig. 2 shows a diagrammatic sketch of a female flower cut through longitudinally. The male flower is yellow right down to its stalk, and on opening exposes a central white slender column surrounded by two rings of tiny yellowish rounded projections. These are the anthers, which soon split and set free the pollen as a slight yellow dust. (A section of a male flower is shown in Figure 3.) The pollen grains carry the male generative cells and if transferred to the stigmas under the proper conditions (pollination) they may germinate and fertilise the female. Subsequently the ovary will grow and become a fruit containing three or, rarely, more seeds. The whole of the woody fruit wall and the outside layers of the seed, including the hard outer coat with its characteristic colour and markings and shape, arise from purely female tissue, and, though development does not take place without fertilisation, no male substance enters into them. The embryo, which lies in the middle of the seed and later grows into the seedling, is, on the other hand, the direct product of fusion between the male and female germ cells, and inherits a mixture of the characters of both parents.

3. The Natural Pollination Process.

The method by which the natural pollination of the flower is brought about determines the parentage of the seeds, that is whether they are the offspring of but one tree or of two different parent trees.

Two general types of pollination occur in plants that have separate male and female flowers. In one of these the pollen is transferred from the stamens to the stigmas by wind, and in the other by insect visitors. The structure of the flower of Hevea, the stickiness of its pollen and stigmas and the presence of an attractive scent and colour indicate that insect pollination is the most probable method, although so far positive evidence from actual observation is lacking.

Many kinds of insects may be seen flying round the inflorescences and several workers in the Dutch East Indies have observed the flowers being visited by bees, flies, moths and beetles of several families, but they do not state that these insects were actually seen to enter female flowers.

During the flowering season of 1928 the same families of insects have been seen on Hevea inflorescences in Malaya. Three

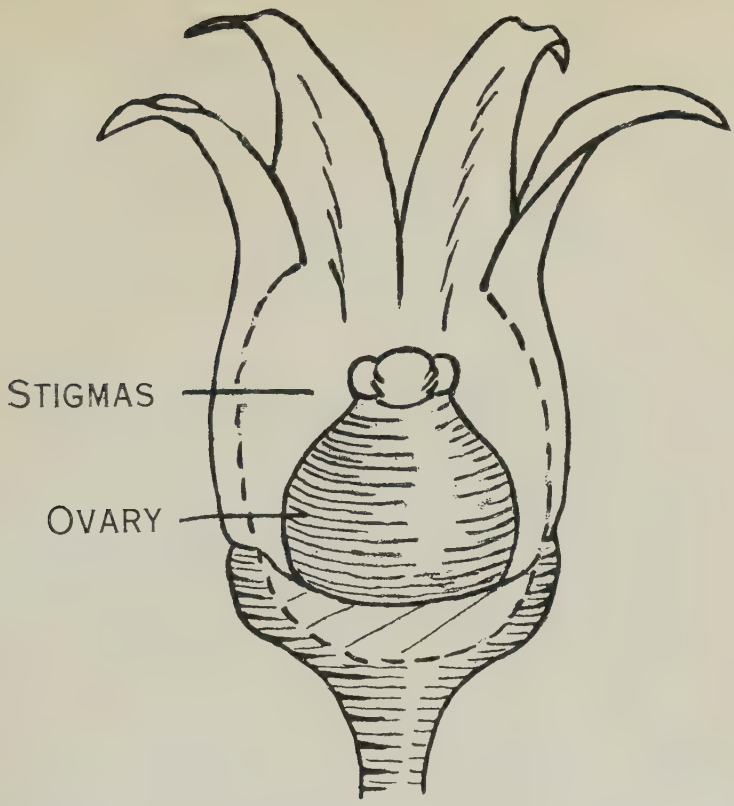

FIG. 2

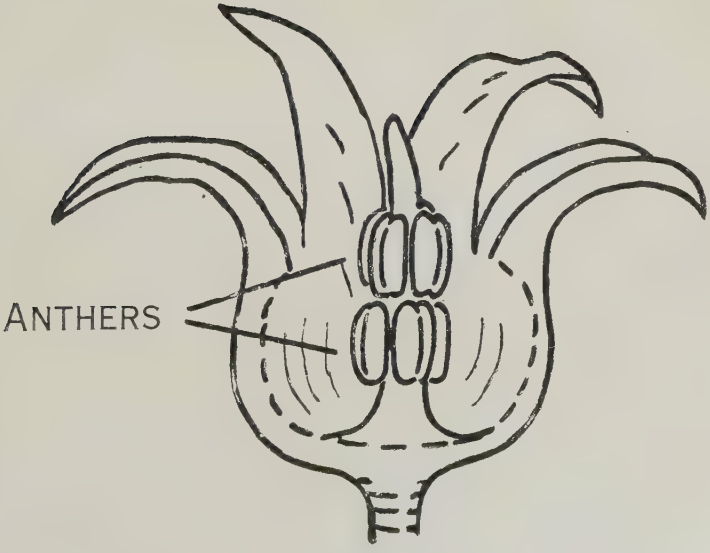

FIG. 3

or four sorts of bees have been frequently watched while visiting the male flowers for pollen and have then been captured and examined. The baskets on their legs have been observed to be filled with pollen, which under the microscope has been identified as that of Hevea. Nevertheless, so far, not one has been seen to enter a female flower, the nearest cases being two which paused on the edge and then turned away.

Smaller numbers of bugs, caterpillars, weevils, ladybirds and other beetles, flies and ants have also been observed. The bugs and weevils may puncture the flowers, and the caterpillars and some of the beetles eat them but the ants appear to take no interest whatever in the flowers. Occasionally flies have been seen entering male flowers, but the only insects seen with certainty in a female flower have been two minute beetles and one tiny fly, which walked all round the petals without touching the ovary and so could not have carried pollen to the stigmas. It appears probable, nevertheless, that the more numerous and active bees are responsible for pollination.

The part played by insects in general has been demonstrated, in the Dutch East Indies by Maas (7) and now in Malaya, by covering inflorescences with muslin bags to keep out insects and so preventing the flowers from setting fruit. In the course of pollination experiments that were started on Pilmoor Estate, Batu Tiga, Selangor, in the first flowering season of this year over thirty inflorescences with about two hundred female flowers and very many more males were enclosed in insect proof bags and not one fruit was formed.

It might appear that the right insects for pollinating Hevea are not present in the East, for though the rubber tree produces such a mass of blossom very few female flowers develop into fruit. For example in Java Maas (7) found that only 2 to 3% of female flowers set seed—in one series of observations 20 out of 927—and Heusser (2) says that on the average only one fruit forms for seventy-two female flowers.

4. Artificial Pollination.

If insects do actually pollinate Hevea it is possible that when collecting pollen they will visit several trees in one excursion, and so the female flowers may receive pollen from males on the same or other trees. In that case seed picked from one tree will have a known mother but its male parentage will be unknown.

For accurate breeding experiments, however, it is essential to know both parents and recourse must be had to artificial pollination.

In the method used this year on Pilmoor Estate suitable inflorescences were selected and all open flowers removed. If the females were to be used all the male buds were cut off also, lest they should open later and their pollen reach the female flowers during subsequent handling. The prepared inflorescence was enclosed in a muslin bag supported on a light wire frame and left until the flowers began to open. Male flowers from another tree were taken to the mother tree and the bag opened temporarily, so that the anthers could be picked out with sterile forceps and transferred to the stigmas of the female flowers, which were enclosed again for a few days until the petals had withered and the stigmas had turned brown, showing that they were no longer suitable for the reception of pollen.

After carrying out these operations everything may be left to proceed naturally. If pollination has not been successful the female flower withers and falls within two or three weeks but if fertilisation has ensued the ovary begins to grow, slowly at first but more rapidly during the second month, until, unless previously damaged or diseased, it reaches full size after $2\frac{1}{2}$ or 3 months. (Fig. 4) Internal growth and development of the seeds then goes on and the fruit ripens about 2 months later.

5. Breeding Methods.

With both plants and animals breeding methods generally fall into the two classes of "inbreeding" and "crossbreeding". In the first method individuals that possess the desirable characters in the highest degree are alone chosen as parents. The type is then purified by breeding only from close relations, as with animals, or in most plants between different flowers on the same plant or even from one flower alone. From each generation only those offspring that come nearest to the desired type are selected and used as parents for the next. Thus at each step the characters sought for are intensified, until after a few generations a strain is obtained that will breed reasonably true to type. It must be remembered, however, that no new hereditary factors can be brought in by this method, and if the full expression of a certain charactor is determined by the combination of several inherited factors (and many such characters are known in genetics) but all are not present in the original parents, then no amount of continued inbreeding will produce a race with that particular character developed to the fullest possible extent.

If, however, cross-breeding is employed between parents possessing different hereditary constitutions one of them may carry one or more of the determining factors not present in the other, and when these sets are re-combined in the next generation some of the seedlings may inherit the complete set and so exhibit the greatest possible development of this character. Subsequently the new strain may be preserved by inbreeding and continued selection.

It is very probable that the latex yielding capacity of Hevea is a complex character determined by all the hereditary factors that influence latex vessels, girth, quality of latex and so on, and thus one high yielding tree may be genetically different from another, neither having a complete set of factors and neither being the best ultimately possible.

6. Experiments in Self-Pollination.

With the limitation just mentioned selfing gives the quickest route to the production of a uniform race; but in the case of Hevea this could not be accomplished quickly as each generation takes several years from seed through tapping tests to seed again. The greatest drawback, however, is that not all Hevea trees are suitable for this method of breeding for most appear to be self sterile, i.e. pollen from the male flowers will not fertilise female flowers on the same plant.

Maas (7) and Heusser (3) in the Dutch East Indies have published the results of experiments in self pollination and their successful pollination in 1919 and 1920 respectively averaged 1.7 and 0.8 per cent. of their attempts, and though one tree gave as much as 6.9% of success, nine out of the fifteen studied gave none at all.

Heusser (4) states, however, that in some cases the sterility of the mother tree was lost to some extent between its budded offspring and pollination became successful. Unfortunately this does not occur always. During May and June of this year two of the highest yielding budded clones—A 44 and B 58 on Pilmoor Estate were tested for self sterility. Flowers on a number of trees were pollinated from other trees in the same clone and from male flowers on other parts of the same tree or on the same inflorescence. Altogether 154 flowers of A 44 and 255 of B 58 were pollinated but without a single success.

7. Crossing Experiments.

Experiments on cross pollination have been carried out for several years in Sumatra, and they show that, so far as raising seed is concerned, crossing gives better results than selfing.

In 1919 Maas (7) obtained 42 fruits from 751 cross pollinated flowers, that is 5.6% of successes. The results varied greatly from tree to tree; for example trees No. 4, 5, 6 and 7, gave about 2, 4, 13 and 12% respectively. In 1920 Heusser (3) and his assistants achieved 10.9% of successes from 6716 cross pollinations. With 35 different combinations of 20 parent trees the results again varied greatly. For example in the cross between tree 29 used as the mother and 141 as the father out of 239 pollinations the whole failed. At the other extreme when trees 138 and 146 were employed as the female and male parents respectively 83 successes out of 211, or 39.3% were obtained.

The fruit setting of one mother tree also depended on the father: tree 164 gave no successes with pollen from tree 144, but gave 8.9% with tree 142 while when tree 151 was the male parent 28 fruits were harvested as the result of 132 pollinations, i.e. 21.2% success.

In 1925 Schweizer (8) in West Java made 18% of successful crossings—187 out of 936, and van der Hoop (6) in Java gives his total results as 5% in 1924, 35% in 1925, 8% in 1926 and 6.9% in 1927.

In May and June of this year cross pollination was carried out on Pilmoor Estate between the clones A 44 and B 58. From 143 female flowers of A 44 two fruits are now ripe, and from 260 crosses with B 58 as the mother one fruit only was obtained, that is less than 1% of the pollinations were successful. To illustrate the mortality amongst young fruit, and the uncertainty of results in work of this kind, it may be of interest to follow the hopes of success from these two crosses. Growth of the ovary into the young fruit is first noticeable between two and three weeks after pollination. From 143 flowers of A 44 only 6 ovaries had started to grow in three weeks, and were then about 3mms. in diameter. Inflorescence No. 49 formed 2 young fruits of which the lower dropped off in five weeks and the other in seven weeks. The one fruit on inflorescence No. 50 grew well to 14mms. in seven weeks, but then its stalk was broken by the wind and it was dead a fortnight later. On inflorescence 90 two young fruits were growing three weeks after pollination and both have

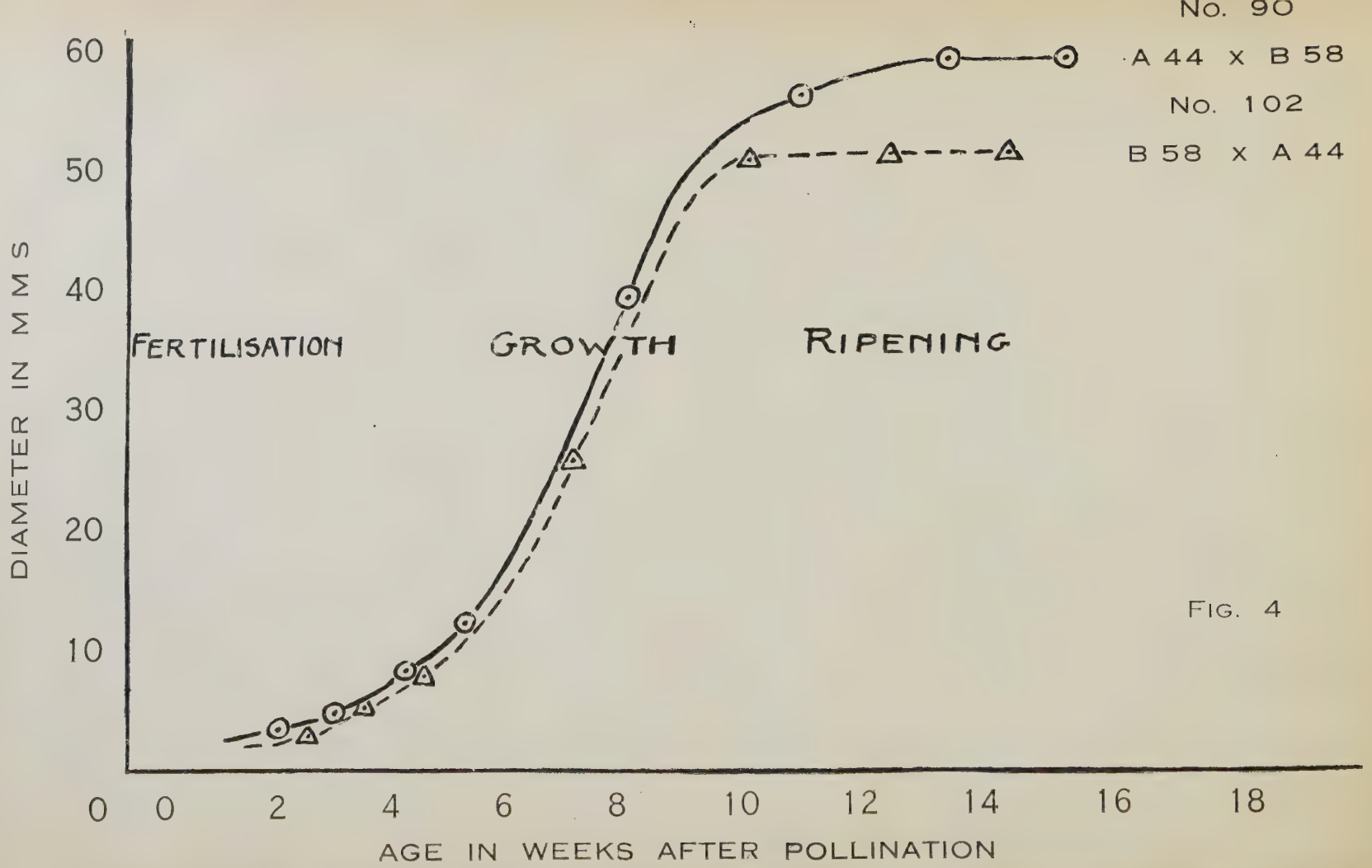
No. 90
A 44 x B 58
No. 102
B 58 x A 44
60
50
40
30
20
10
DIAMETER IN M M S
FERTILISATION
GROWTH
RIPENING
0
0
2
4
6
8
10
12
14
16
18
AGE IN WEEKS AFTER POLLINATION

FIG. 4

survived. The continuous curve of Fig. 4 shows the growth of one of them from the time it was first measured at 2½ weeks after pollination, through the slow growing period and then through the time of rapid growth (from about 6 to 10 weeks) to the final stage of constant size when ripening is proceeding.

Of the reciprocal cross, in which the female parent was B 58, only 3 out of 260 flowers pollinated were alive 3 weeks later. The one on inflorescence 97 died during the next week, that on No. 96 grew to 5mms. and withered between 6 and 9 weeks and only the fruit on inflorescence 102 grew till it reached its full size of 53mms. in 11 weeks. The growth of this fruit for fifteen weeks is indicated by the dotted curve in Fig. 4 and it is of very great interest to note how this also shows the influence of the mother tree on the size of the fruit, for after natural pollination also B 58 fruits are smaller than those of A 44.

Thus of the seven young fruits that were growing one month after pollination only three survived and reached full size. In addition it still remains to be seen whether their seed will be fertile and germinate.

Having emphasised the casualties that have to be reckoned with it may be permissible to quote the apparently greater success of some of the later crosses made in the second flowering season in August in further illustration of the tree to tree differences previously obtained by Heusser. From 261 female flowers of Clone A 8 crossed with A 44 16 young fruits have survived for five weeks. The four oldest have now lived for seven weeks and are about 18mms. in diameter. Of the 39 flowers of A 44 crossed in the reverse way all have died though one was still growing at 3 weeks. Other combinations of clones are still more hopeful. For example four weeks after pollinating 57 flowers of A 44 with D 61 pollen ten young fruits are alive, while the reciprocal cross has given about twenty potential successes from a hundred pollinations. Thus even allowing for severe casualties these crosses promise to be considerably more productive of fruit than those between A 44 and B 58, though on the other hand one or two others probably will be even less successful.

It is obvious that much more remains to be learned about the conditions necessary for success before a sufficiently satisfactory procedure for estate work can be recommended, but, on the other hand, it is distinctly encouraging that such a degree of success has attended the first efforts in this direction.

Although better results are obtained from artificial crossing than in nature or by selfing, still many female flowers have to be pollinated in order to obtain a few fruits. Various attempts have been made to find a method of increasing the chance of success or explaining the failures. Schweizer considered that his experiment was affected by the weather, and van der Hoop's variations from year to year taken with known results for other crops suggest that weather may exert a large influence. For instance, the time of day at which the flower buds open and at which the pollen is set free is affected, and is later on a dull and moist day than on a bright and dry one.

Maas (7) studied the effect of pollinating at various stages of opening and, on the whole, obtained the highest success by using male and female flowers on the morning after opening, less from just opened flowers, and least from females at the midday after opening with the use of fresh pollen. With one tree, however, these last conditions gave better results. The differences were, nevertheless, not great enough to balance the practical difficulty of using flowers at one stage only, for this reduces the number of pollinations that can be made, and any such programme is very liable to be upset by rain. It is hoped to obtain additional evidence on the effect of the conditions under which pollination is carried out from the results of this year's work on Pilmoor Estate, in which now over 2,200 flowers of 8 clones have been pollinated in all possible stages.

The hopeful possibilities of crossing as a means of producing high yielders are illustrated by Heusser's (5) results in Sumatra. Twenty seedlings from a cross made in 1919 between trees 36 and 35 averaged 11.2 grams per tapping in their first tapping period from May 1924 to October 1925, as compared with 8.7 grams for Clone 35, that is for buddings from the male parent of the cross. The best seedling gave 21 grams and the best budded tree only 14, while the seedlings have maintained their superiority in subsequent years. The best trees have been multiplied by buds, marcots and further crossings so that now tapping results are being obtained from a second generation cross made in 1923.

PLATE I.

RIPE FRUITS FROM 1928 ARTIFICIAL POLLINATIONS

A44 FEMALE X B58 MALE

B50 FEMALE X A44 MALE

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BUDDING IN THE FIELD.

By C. E. T. MANN.

1. Introduction.

In present plantation practice it is recognised that the budding of Hevea may be carried out either in nurseries or in the field. It is not intended in the present paper to discuss the rival merits of the two methods; it is sufficient to state that in Malaya at least field budding is carried on to a great extent. It is therefore important to gain more detailed knowledge of the factors affecting the success of the operation under field conditions. Clearly, there will be some factors to be considered which are common to both field and nursery practice and in these instances any information obtained may prove of equal value in both cases.

2. Field Work.

In April of this year the writer was afforded an opportunity to carry out a budding programme on an area of 50 acres. The results obtained and observations made during the course of the work form the subject of the present account.

3. Stocks.

The clearing was planted in February 1927 with basket plants alternating with stumps, the whole of the planting material being raised from seed collected from a recorded, high yielding area on the estate. Planting was on the square system, the planting distances being 20 ft. x 10 ft. Where the original basket plants had failed "stumped" plants had been used as supplies.

4. Budwood.

Budwood was obtained from an adjoining area of vigorous young budded trees planted as "stumps" in late 1924. Test tapping experiments were in progress on this area and the three most promising clones were selected for use in the new clearing. Sufficient budwood was cut in the early morning for each day's work and any excess was used on the following day before a fresh supply

was cut. In this way material in the best possible condition for use was obtained and the risk of failure due to dry or bruised budwood was minimised. Having been sawn into convenient lengths the sticks of budwood were rolled in damp sacking for removal to the clearing where care was taken to protect the bundles from exposure to the sun.

5. Budding.

The original basket plants or the "stumps" supplied if these were well established, were budded. In the first period of the work two experienced men were employed; later a third man of similar experience and a fourth who had received a short training were also employed. The usual "patch and tongue" method was used throughout. Each budder was followed by a cooly who tied a shade of leaves in position over each completed budding and also fixed around the base of the plant a wire hoop bearing a metal label stamped with the clone number (and the number of the tree in the clone from which the budwood had been taken). It may be mentioned that this method allows a skilled man to carry on his work without interruption and the man who does the incidental work is able to learn a good deal by observation. In this way an efficient gang may be built up from a small nucleus of skilled budders.

It should be stated that the work was not continuous, the four men being employed for short intervals as they became available. Budding was therefore carried out under varying conditions.

6. Recording.

To facilitate the work of recording and supervision the area was divided into smaller blocks of about ten acres each. Buddings in each block were made from two clones and the combination was changed for each successive block to obtain the desired distribution of the three clones used. A permanent stake bearing a board on which was stencilled in correct order the numbers of the clones used was placed opposite the first tree of each block. This method of subdivision simplifies the work of recording and labelling and avoids the confusion which attends the use of unwieldy numbers. A small plan of the area showing subdivisions and the numbers of the clones used in each small area can be used both for quick reference during the actual budding operations and at later stages.

During the progress of the work the following observations and records were made:—

1. Source of budwood, clone number and the number of the tree from which the wood was taken, with observations on on its condition.
2. Notes on growth condition of individual stocks whether stumps or basket plants, at the time of budding and later when the buddings were opened.
3. Individual records of the work of each man.
4. The complete record of successes and failures at "opening", at"ringing" and again at the first pruning of the stock about ten days after ringing.
5. The daily rainfall observations over the whole period obtained from the estate records.

7. Results.

For the purpose of this account the men employed in budding will be referred to as A, B, C and D, and the clones used as Clone No. 1, No. 2 and No. 3. As the results are to a great extent numerical they are best presented in tabular form.

Table 1. Summary of the results obtained in a field budding experiment with three clones.

Clone.	Number of Buddings Made.	Successes at Opening		Successes at Ringing		Successes Final.	
		No.	%	No.	%	No.	%
1	1518	1404	92	1125	74	1101	72
2	1257	944	75	666	53	664	53
3	779	574	74	472	61	471	60
Total and mean percentages.	3554	2922	82	2263	64	2236	63

The figures summarised above show to what extent the success obtained varied for the three clones used. Clone 1 appears to bud more successfully than either of the other clones. A second point of special note is the very serious loss which occurred between the opening and ringing operations. Budding was carried on during

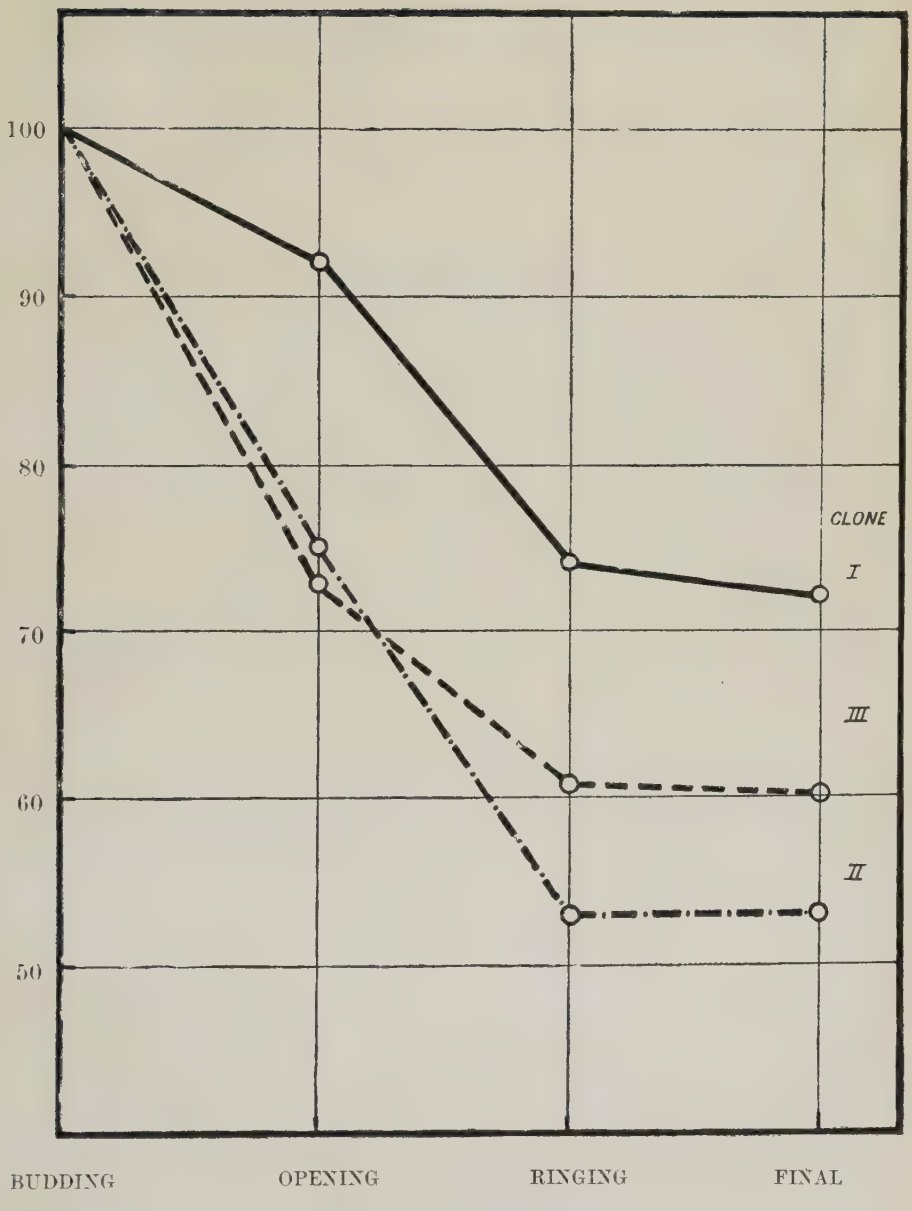

FIGURE I.—A comparison of the results obtained in budding with three different clones under field conditions (Based on data given in Table I.)

part of April, May and June and the losses varied greatly in different periods. This point will be further discussed when the effects of weather conditions and growth of the stock are considered in more detail.

8. Factors Affecting Success.

(1) *The Personal Factor.*

In such an operation as budding the personal factor, the skill of the operator, is of the first importance. In the work under review, A, B and C were all skilled men of considerable experience. It is therefore interesting to compare individual results where work was carried out with analogous material under the same general conditions. Examples of such comparisons, (Table 2) taken from the complete records, show that even with skilled men the variation in success attained may be considerable. It is likely that the variation will be even greater with less experienced budders. The examples quoted show that the quality of the work varies from day to day but this may be due partly to differences in the material used or to different working conditions, or to a combination of both. The work of B is consistently better than that of A and B's superiority is most marked in work with Clone 2, the one which was most difficult to bud successfully.

(2) *The Condition of the Stock and the relation between growth and success in budding.*

It is generally stated that with suitable budwood best results are obtained when the plants budded (stocks) are in active growth or when there is a "strong flow of sap". The growth of a young rubber plant in the first two or three years is somewhat peculiar. Extension growth is carried on by a vigorous terminal bud which passes through phases of very vigorous activity, each active period being followed by a period of rest or dormancy. During the vigorous phase young leaves are formed, the intervals between them becoming smaller as growth slows down until with the cessation of terminal activity the leaves are crowded together forming the typical "whorl" which marks the close of a single growth phase. The terminal bud becomes dormant some time before the leaves reach their full size and the reddish green drooping foliage of the "new storey" or growth phase, is a characteristic feature of vigorous young seedlings at this stage.

In the present work notes were taken on the individual growth condition of about two thousand stocks, both seedlings and stumps, at the date of budding and again when the buddings were opened from seventeen to twenty-one days later. From these observations

TABLE II. *A comparison of the results obtained in budding by different operators under comparable conditions.*

Example No.	Date.	Clone.	Tree Number.	A.		B.		C.		D.	
				% Success at opening.	% Final success.	% Success at opening.	% Final success.	% Success at opening.	% Final success.	% Success at opening.	% Final success.
I	17.4.28	1	29	80	20	95	24				
	17.4.28	,,	30	97	80	97	88				
	18.4.28	,,	116	77	61	86	75				
	19.4.28	,,	157	91	63	90	74				
	23.4.28	,,	45	85	73	92	77				
	23.4.28	,,	115	63	47	92	73				
	24.4.28	,,	115	76	65	84	63				
	...	,,	Average	81	59	91	68				
II	20.4.28	2	370	30	26	75	54				
	21.4.28	2	358	42	39	85	81				
	...	,,	Average	36	32	80	66				

III	25,4.28	3	276	81	65	91	88	81	75	...	...
	25,4 28	„	287	80	70	84	70	77	54	...	...
	...	„	Average	81	68	88	79	79	65	...	...
IV	26,4.28	3	395	62	50	...	...	81	81	...	...
	27,4.28	„	294	56	42	...	...	65	53	...	...
	28,4.28	„	315	68	58	...	...	83	69	...	...
	„	...	Average	62	50	...	...	76	68	...	...
V	12,5.28	1	145 137	...	...	100	96	...	...	98	93
	14,5.28	1	138	...	...	100	95	...	...	100	89
	„	...	Average	...	...	100	96	...	...	99	91
VI	10,5.28	2	364	...	...	93	91	78	74	93	90
VII	11,6.28	2	350	84	50	...	...	...	...	92	60
	12,6.28	2	368	92	29	...	...	...	...	87	35
	„	...	Average	88	40	...	...	...	...	90	48

the stocks have been divided into five main groups or growth classes, and the number of successful buddings made in each class have been recorded. The results are summarised in Table 3.

Table 3. Results obtained in budding of stocks in varying stages of growth activity. (Success is based on the final number of growing buddings).

Class.	Growth Condition of Stocks.		Results.			
	At Budding.	At Opening.	No. Budded	Successes.	Failures.	% Success.
I.	Dormant	Dormant	437	174	263	40
II.	Dormant	Terminal growth beginning	321	198	123	61
III.	Dormant	Vigorous	413	296	117	72
IV.	Vigorous	Vigorous	252	184	68	73
V.	Vigorous	Dormant	427	269	158	63

The figures presented in Table 3 show that the best results were obtained on vigorously growing stocks. The comparatively poor results obtained on stocks in a dormant condition are of particular interest and a further reference to this observation will be made when the influence of weather conditions is considered.

In the accompanying figure (Fig. 2) the normal growth curve of a young rubber plant between two periods of rest is diagrammatically represented. This curve may be divided into sections corresponding with the growth classification given above. (Table 3).* The results obtained in budding plants falling within each class are shown in the diagram and the striking relationships between the vigour of the stock and the success of the operation is clearly shown.

(3) *Type of Stock.*

Where stump supplies had made good growth they were budded at the same time as the original basket planted stocks. Approximately six hundred stump supply plants were budded in the first

*For the purpose of diagrammatic presentation Classes III and IV in Table 3 have been combined.

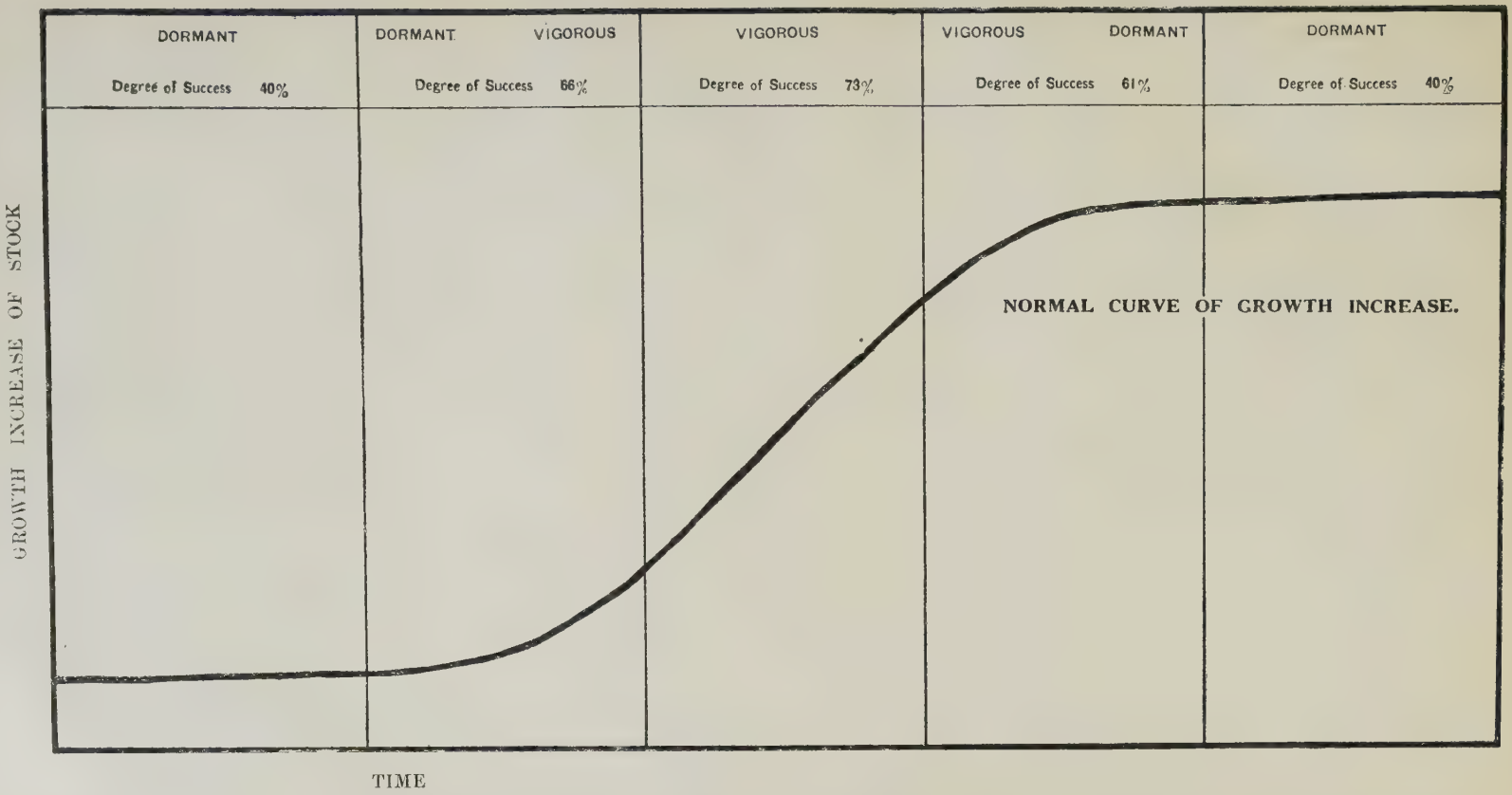

FIGURE II.—Showing the relation between the vigour of growth of the stock and success attained in the budding operation. It will be noted that the best results were obtained on stocks which showed vigorous growth throughout the period from budding to opening.

three blocks (28 acres) and a comparison of the results obtained with those obtained on seedling stocks is made in Table 4.

Table 4. Comparison of the results obtained in budding with three clones on "stumps" and seedling stocks.

Stocks.	Stumps.					Seedlings.				
Clone.	Number Budded.	Success on Opening	%	Successes Final.	%	Number Budded.	Success on Opening.	%	Successes Final.	%
No. 1	190	161	85	127	67	467	402	86	308	66
No. 2	183	127	69	112	61	569	407	71	376	65
No. 3	212	152	72	124	59	565	418	74	342	61
Totals & mean %ages.	585	440	75	363	62	1601	1227	77	1026	64

Examination of the results summarised in Table 4 shows that in the present experiments there is little significant difference in the results obtained on the two different types of stock. The small apparent superiority of seedlings over "stumps", amounting to about two per cent., cannot be regarded as sufficiently large to be significant.

(4) *Condition of Budwood.*

It has already been shown (Table 1) that the success obtained varied with the three clones from which budwood was taken. Further, the results summarised in Table 2 indicate that within a single clone the degree of success attained may vary with individual trees from which budwood is obtained. Although in many respects budded trees of the same clone show much greater uniformity than seedling trees of mixed parentage yet both buddings and seedlings are equally subject to environmental influences. Thus in an area planted with trees of a single clone differences in vigour due to soil differences or special advantages of position will be encountered. It has been noted that trees of the same clone growing under apparently uniform conditions do not flower at the same time neither do they all go through the wintering stage together. Both flowering and leaf fall are the outward evidences of changes in internal condition. Such differences will affect the quality of the budwood obtained from different trees.

Examples have been selected from the full records illustrating this possible variable factor. In the cases summarised in Table 5 each set of buddings was made by the same man working under the same conditions with budwood obtained from different trees of the clone specified.

Table 5. Variation in the success obtained in budding under uniform conditions with budwood from different trees of the same clone.

Clone.	Tree Number	Date.	Number of Buddings made.	% Initial success.	% Final success.
1	29	17.4.28	38	87	24
	30	,,	83	97	83
	116	19.4.28	20	95	90
	157	,,	42	90	74
	45	23.4.28	122	89	75
	115	,,	69	78	60
	145	12.5.28	42	100	95
	137	,,	62	98	94
3	276	25.4.28	93	85	77
	287	,,	119	82	64
2	370	20.4.28	176	52	40
		28.6.28*	131	51	40
	358	21.4.28	90	67	62
		29.6.28*	44	77	77

*Rebudding. Results obtained with budwood from the same two trees.

In the examples given above those given for Clone 2 need a further word of explanation. Failures and supply plants not suitable for budding in April, were budded in late June with buds

obtained from the same two trees. The budwood from tree 370 gave consistently poorer results than that from tree 358.

(5) *The Influence of Weather Conditions.*

It is common knowledge that the success of the budding operation depends to a certain extent on weather conditions. For example, during rain or heavy morning mists it is impossible to ensure the degree of cleanliness in the actual operation which is essential for success. During the heat of midday, the physical discomfort of the operator makes for poor work and it is often advisable when budding under field conditions, to stop work early and start again in the cooler hours of the afternoon. But these are conditions affecting the actual budding operation and further information is required on the conditions which make for success or failure between the time of budding and the commencement of growth of the grafted bud.

In the present work it has been shown that the margin of failure varies considerably with the skill of the operator, and the quality of the material used. It is therefore impossible to make a close comparison between success and daily weather conditions. The whole period over which the work was carried out is divisible into two well defined showery and drought periods. From the middle of April to the middle of May there were fourteen rainy days and the total rainfall was 11.23 inches. From the middle of May to the middle of June a total of 1.29 inches of rain fell on seven days. In the whole month of June rain fell on only 5 days and totalled 0.88 inches. It is of interest in view of these records to examine the results obtained in budding in the two periods April—May:—showery; May—June:—drought. (Table 6).

Table 6. Influence of weather conditions on budding in the field.

Clone.	Period of Budding.	No. of Buddings.	Percentage Initial Success	Percentage Final Success.	Losses after opening as a percentage of initial success.
No. 1	Showery	493	98	84	14
	Drought	190	99	70	29
No. 2	Showery	361	88	85	3
	Drought	502	80	35	56

Caution must be exercised in any attempt to separate one factor from the complex of factors which influence the success of such

an operation as budding but the results obtained under the diverse weather conditions described above are very suggestive. The high initial success at the first examination (success at opening) shows that the quality of the actual technique did not change very appreciably. The greatest losses occurred between the first and second examination (at ringing) and point to the influence of some external factor or complex of factors.

(6) *Losses After Opening.*

In field budding it is the usual practice to protect the completed budding from exposure to sun and rain by tying a shade of leaves around the freshly budded stock immediately above the waxed binding. As a further precaution, in exposed situations this protective shade is renewed after the budding is opened and the bud-patch proves to be alive. In all the buddings made in April the first of these precautions was made the rule and the second, shading after opening, was practiced where the exposure seemed to warrant extra protection. When the first buddings were ringed on May 21st a large percentage of losses was recorded. More attention was subsequently paid to shading after opening, more leaves were used to make a thick shade, the "tongue" was not cut or broken off but allowed to cover the bud lightly, and in addition a split bamboo, about eighteen inches long and semi-circular in cross-section, was forced into the soil close to the stock and opposite the point of budding. By this means losses after opening were considerably reduced which is shown by the results summarised in Table 7.

Table 7. The effect of shading young buddings at "opening" on the final success obtained....(Figures do not include buddings made under drought conditions of June).

Clones.	Extent of Shading.	Number of Buddings Made.	Percentage of Initial Success.	Percentage of Final Success.	Losses after Opening as a Percentage of Initial success
Nos. 1, 2, & 3.	Light or none	1659	76	62	19
No. 1 & 2.	Heavy	960	90	81	10
No. 1.	Light or none	348	91	70	23
	Heavy	283	99	87	12
No. 2.	Light or none	266	57	48	17
	Heavy	302	88	84	4

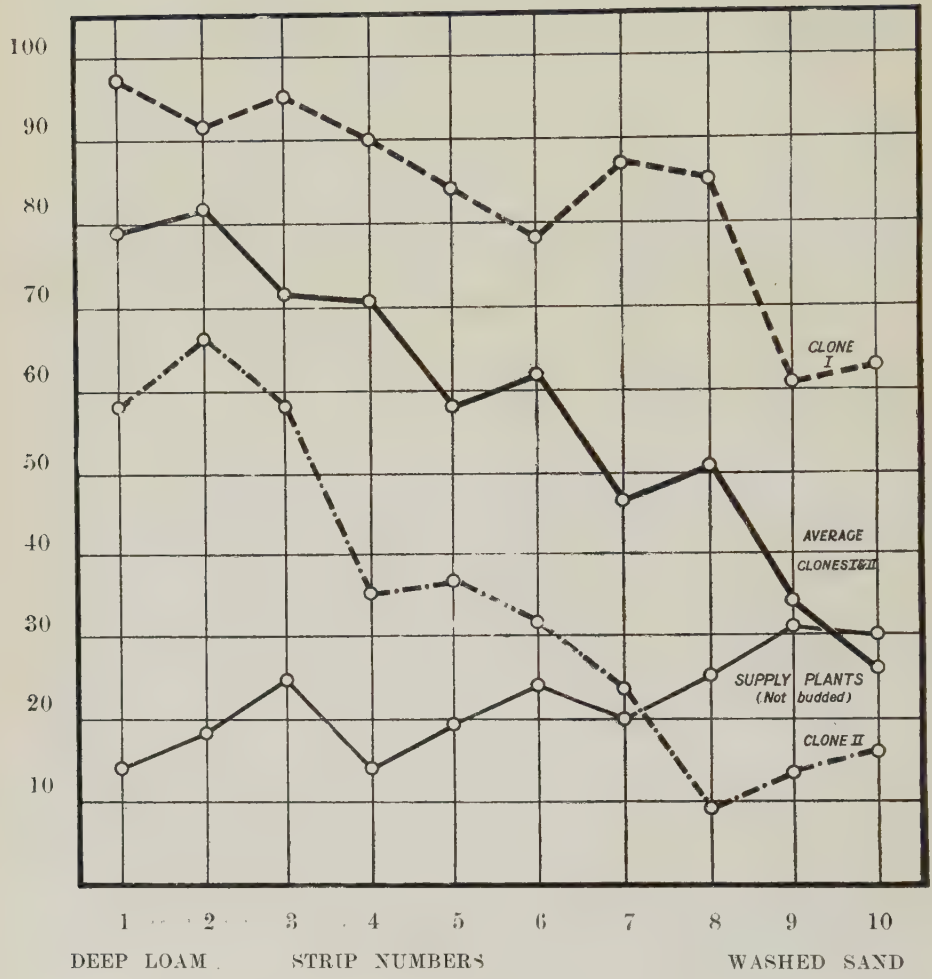

FIGURE III.—An area of 12 acres is divided into 10 strips of equal area. The character of the soil changes from a deep loam to a washed sandy soil in the direction indicated in the diagram. The percentages of successful buddings made in each strip are shown. Buddings of Clone I were made in a showery period and those of Clone II were made under drought conditions. There is a general increase in the percentage of supply plants with the change of the soil from loam to sand.

Under the severe drought conditions which obtained in June, even though the shading precautions described above were employed, heavy losses of apparently successful buddings were experienced. For example, in one block alternate rows were budded with Clone 1 in May; 493 buddings were made, 485 were alive on opening, giving finally 416 growing buddings. The remaining rows were budded in June with Clone 2; 502 buddings were made of which 411 were alive on opening but of these only 178 survived.

The effect of the drought on the growth of the stock plants during this period merits special description. In numerous instances terminal growth had just commenced early in the dry period. The subsequent growth of these plants was very different from the usual growth of a "new storey". Extension was very slow and in place of the usual, drooping reddish green foliage small dwarf leaves were produced which failed to mature and dropped in a few days. The new "storey" of growth, which under normal growing conditions would have been at least two feet in length, was represented by a slightly swollen cork-covered dwarf shoot devoid of leaves and seldom more than six inches long. On these shoots numerous small buds were present in a close spiral formation as shown in the accompanying illustrations. (Plates I and II). The close relation between the vigour of the stock growth and success in budding has already been shown. It is therefore of especial interest to note the poor results obtained under drought conditions which produce such a severe check to normal growth as that described above.

(7) *The Influence of Soil Character.*

In a block of 12 acres, which was one of the sub-divisions comprising the area budded, it was noted in passing through the area from the left to the right that the character of the soil changed markedly. The soil on the left side of the block was a deep medium loam, on the right the soil was practically a pure white quartz sand containing very little clay. The growth of the stock plants was poor in this region but improved gradually towards the left of the area with the change in the character of the soil. There had been considerable difficulty in establishing young plants in the very sandy soil as evidenced by the large number of recently planted supply plants recorded.

In budding on this block the largest number of failures was recorded in the white sand region. With Clone 1, budded in good weather conditions this was clearly shown and in budding with Clone 2 in the drought conditions of late May and June the losses in the same region were heavy. These records are graphically represented in Figure 3.

9. Discussion of Results.

In the foregoing account of results and observations it has been possible to analyse and compare the results obtained in budding in the field under a variety of different conditions.

Given good technique and a reasonably high standard of work on the part of the operators, success depends on two main sets of factors. The first group includes such factors as (a) the condition of the plants to be budded, their state of growth and general vigour during the early stages of the union of the bud and the stock and (b) the condition of the budwood. The second group includes those factors which are best described as environmental and the influence of weather conditions and soil characters will be considered under this head. Failure may be due to a combination of environmental factors and defective material, for example dry conditions may so curtail the growth of the stocks as to make them unsuitable for budding. The distinction between the two sets of factors is therefore not a hard one and a combination of factors of both groups may influence the results obtained.

The results obtained and observations made on stocks of different types in varying stages of growth (Tables II and IV, Figure 2) show the most important factor which influences the success obtained is that of growth vigour. Whether the stocks budded were stumped plants or seedlings the success attained in budding varied in direct ratio with the observed vigour of growth during the important early stages of union of the tissues of the bud patch with those of the stock. In the field, where a small number of stocks are scattered over a comparatively large area, the differences in vigour of growth are far greater than those observed in a nursery established for budding. Under nursery conditions it is possible to choose stocks in the best stage of growth for the operation; under field conditions choice is much restricted and failures are more numerous in consequence.

Budwood from different clones has been shown to give varying degrees of success. This variation suggests inherent differences in the characters of the clones used. From anatomical work at present in progress it appears likely that peculiarities of bud structure may account in part for these differences. For example, examination of samples of budwood of different origin reveals differences in the character of the bud formation. In some cases there is a marked swelling of the shoot at each bud, so that when a bud patch is prepared the inner, cambium surface is markedly concave with the core of the bud projecting slightly from the base of the hollow.

When such a bud patch is placed in position against the cambium of the stock this hollow must be filled with new living cells before union can be established. Further, in binding a budding of this type there is more risk of damaging the delicate cambium tissues by uneven pressure and thus reducing the chances of a successful union.

Just as the trees in the ordinary plantation show a wide range of vigour so different clones, each derived from a single mother tree, show similar wide differences. Where budwood is cut from more mature budded trees these differences will be reflected in the quality of the material obtained. Apart from this general variation between different clones differences have been shown to exist between different trees of the same clone (Table V). The reasons for this variation between individuals of the same clone require further investigation. In part they are no doubt due to the normal variation in the vigour of different trees which results from differences in soil character and position but this is probably not the complete explanation. It is well known in other branches of agriculture where budding and grafting methods are extensively employed that the growth vigour of budded plants of a single variety can be greatly modified by budding on mixed seedling stocks. Where budwood is obtained from multiplication nurseries more uniform results may be expected since the differences in vigour which characterise the trees in later years are hardly noticeable in the first year of vigorous growth.

It is evident that the success of the budding operation is dependent to a great extent on the condition of development both of the buds used and the stocks budded. Factors influencing this development will affect indirectly the success of the budding operation. For vigorous growth a plentiful, available supply of water is a first essential and where the supply is restricted, owing to unfavourable weather or soil conditions, growth will be impaired. The results obtained in budding under drought conditions, summarised in Table VI, show clearly the marked increase in the number of failures compared with the number recorded under less dry conditions. The effects of the drought were most marked in plants growing on a loose sandy soil with a low water holding capacity and it is of interest in this connection that the largest number of failures in budding was recorded in the same area (Figure 3). Little can be done in extensive field operations to counteract the effects of drought and budding is best discontinued until conditions become more favourable.

Climatic factors may have a more direct influence on the success of budding operations in the field. On opening a young bud-

ding a partially healed wound is exposed. Unless this wound is protected from direct exposure to the sun rapid drying of the newly formed, wound healing cells (callus) takes place and the bud patch frequently dies. If the operation is not carefully carried out in the first place so that wide gaps separate the edges of the patch from the cut edges of the bark of the stock the danger of loss from exposure after opening is increased. A good fit of patch and panel leaves only a small amount of wound healing tissue exposed and dangers of drying out are proportionately reduced. Careful attention to shading the freshly opened buddings has been shown to reduce the percentage of subsequent losses (Table VII). The split bamboo used in this connection is allowed to remain in position during the early stages of growth of the bud. By this means erect growth of the budding is obtained and the extra support of the bamboo in the early stages of growth prevents losses from mechanical damage.

Summary.

1. In the foregoing the results obtained in a field budding experiment are presented and discussed.

2. The percentage of successful buddings made varied with the three clones used and with the condition of the budwood obtained from different trees of the same clone.

3. Best results were obtained where the stocks budded were in a condition of vigorous growth during the period between budding and opening.

4. There was no significant difference in the degree of success obtained with basket planted seedling stocks and stumped plants where these were well established.

5. By the careful shading of buddings immediately after opening losses from exposure were greatly reduced.

6. Budding under drought conditions gave poor results.

7. The severe check to growth due to dry conditions, especially on a sandy soil, is discussed in relation to the success of the budding operation.

8. Reasons are advanced to account for the lower percentage of success attained in budding in the field as compared with budding in the nursery.

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Plate II.

PLATE III.

DESCRIPTION OF PLATES.

Plate I.—(a) Shows the effect of drought conditions on the growth of a young rubber plant. The main shoot and lateral shoots show much restricted growth and numerous small buds in a close spiral formation are present.

(b) Detail of abnormal bud formation on the terminal shoot of the seedling shown in (a).

Plate II.—(a) Further example of the drought effect described in the text.

(b) Recommencement of growth. The terminal shoot grows slowly and vigorous young lateral branches are frequently developed.

Acknowledgment.

The experimental work described in the foregoing account was carried out on Pilmoor Estate, Batu Tiga, Klang. The author is indebted to the Pilmoor Rubber Company for the facilities afforded for the work and especially to Mr. W. H. Bragg, the Manager of the estate, for his constant assistance and interest during its progress.

NOTES ON DEFECTS IN SMOKED SHEET AND CREPE RUBBER.

By R. G. FULLERTON.

In the following paragraphs a general account is given of the characteristics and the nature of commonly occurring defects in smoked sheet and crepe rubber, and of the principles underlying methods for their prevention as recommended for estate practice. Many of the defects referred to have no harmful effect on the quality of the rubber after vulcanisation, and in the majority of cases the only reasonable excuse for their classification as defects is the unsightly appearance which they impart to the raw product. Since, however, standards of quality at present imposed by the Market are based largely on appearance alone, methods have to be devised to prevent the occurrence of these defects.

A. Smoked Sheet.

1. Moulds.

Moulds and mildew are higher forms of fungi or micro-organisms which, by chemical changes essential to their growth, are capable under favourable conditions of acting on organic substances with which they are in contact. The changes themselves are complicated processes and they are influenced by external conditions such as temperature, moisture, and the presence or absence of oxygen, all of which conditions can be controlled by artificial means. Freshly machined sheet rubber is always rich in the spores of these organisms, and for their growth, adequate supplies of food materials are necessary, even the very small amount of proteinous serum substances which are always present in sheet rubber being sufficiently rich in carbon and nitrogen to foster the growth of mould. A certain amount of nitrogen is also assimilated from the air.

In view of the fact that their growth is influenced by the above mentioned conditions, methods for the prevention of the development of moulds in the first place aim at storage of the prepared sheet in as dry an atmosphere as possible. The temperature of the atmosphere during storage cannot well be regulated in ordinary practice, nor can the presence of oxygen be avoided since the sheets are always stored in the presence of air, and thus it has become

necessary in addition to treat the sheets with antiseptics which retard the development of the moulds. The practice of smoke-drying the freshly machined sheets is extremely beneficial in this respect, since a certain amount of antiseptic creosotic substances contained in the smoke is absorbed by the sheets, and, provided that a sufficiently long period of smoke-curing is employed, there is seldom any necessity for further antiseptic treatment. At present, however, there is an unfortunate tendency to work with shorter periods of smoking than were at one time employed, with the result that the maximum of benefit is not derived from the smoke-curing process, mouldy sheet is thus more in evidence, and additional treatment involving the expenditure of time and money has to be given. It is probable that if the majority of estates were to give the sheet an extra three to four days' smoking much of the present trouble with moulds would be avoided.

The additional treatment referred to consists of the use of para-nitrophenol as an antiseptic, there being two different methods whereby the treatment may be carried out. As the use of this substance is widely practised by estates in Malaya these methods are here described in detail.

(1) *Addition to Latex.*—Para-nitrophenol is soluble to the extent of 3 per cent. in water at 40°C. and hence in effecting solution sufficient time must be given for the substance completely to dissolve. A stock solution of 1 per cent. strength is made and the insoluble impurities which are always contained in the commercial product are removed by filtration through a fine cloth. This solution is then added to latex, standardised to a rubber content of $1\frac{1}{4}$ to $1\frac{1}{2}$ lbs. per gallon, at the rate of 1 volume to 60 volumes of latex. It may be mixed with the latex prior to the addition of the coagulant, or a mixture of the correct quantities of para-nitrophenol solution and coagulant may be added. It may be used in conjunction with acetic acid or with formic acid.

(2) *Soaking Method.*—According to this method a 0.1 per cent. stock solution of the antiseptic is made by dissolving it at the rate of $3\frac{1}{4}$ ozs. of the solid to 20 gallons of water, the same precautions being taken to effect a clear solution. The freshly machined sheets are then placed singly in the solution contained in a suitable receptacle and are allowed to soak for half an hour. They are then removed and allowed to drip for about two hours on racks placed in the open in a well ventilated and shaded site, before being transferred to the smoke-house.

Complete immersion of all the sheets may be ensured by placing boards or planks on top of them, and, by placing them

singly in the solution, the whole of the surface of each sheet comes in contact with the antiseptic. Care must be taken, however, not to overcrowd the sheets during immersion merely to economise in space—$3\frac{1}{4}$ ozs. of the solid para-nitrophenol dissolved in 20 gallons of water is sufficient for the treatment of two batches of sheet of 100 lbs. each. If only one batch of sheet is treated on one day, the solution may be kept for the treatment of a batch of the same size on the following day, the solution being then discarded and a fresh solution used for the treatment of further quantities of sheet.

Notes.—

(a) Para-nitrophenol is usually shipped in drums and is in the form of a cake containing a certain amount of moisture. The most convenient method of handling it is to place the cake in a suitable receptacle such as a Shanghai Jar for about two days, after which it can easily be crushed to a powder.

(b) Samples of sheet treated with this antiseptic may be sent to the Institute for tests for the development of mould. In doing so, the method of treatment should be described.

(c) The sheet should be packed as soon as possible after removal from the smoke-house, preferably after ten o'clock in the morning when the atmosphere is warm and less damp than in the earlier hours. Sheet which is stored in the open absorbs moisture more rapidly and to a greater extent than sheet which is packed, and moisture absorption increases the liability to mould development. All cases should be sun-dried before being packed and, after packing, should not be stored in direct contact with a cement floor. If sheet has to be stored on the estate and the store is badly sited, it may be necessary to adopt both methods of application of para-nitrophenol.

(d) The addition of para-nitrophenol directly to the latex before coagulation on certain estates seems to be associated with the production of bubbles in the prepared sheet. The reason for this is not yet definitely known and the subject is at present under investigation by the Institute.

(e) The results of recent experiments on the development of moulds in smoked sheet and in air-dried sheet are to be incorporated in a special Bulletin.

2. Bubbles.

Bubbles in sheet rubber are commonly spoken of as air-bubbles, or as air-bells, but in the large majority of cases these bubbles

contain larger proportions of other gases such as carbon dioxide, nitrogen, and hydrogen than are normally present in air, and hence it is more correct to speak of them as gas-bubbles. The bubbles usually found in smoked sheet are very small, in some cases microscopic in size, and may be easily observed when the sheet is examined by transmitted light. They may be evenly distributed in the interior of the sheet or may occur in patches, sometimes only on one of the long sides of the sheet, and when examined by reflected light white patches are seen at those parts containing the bubbles, almost giving the impression that the sheet is not completely dry.

In nearly all cases gas-bubbles are formed as the result of fermentative changes which take place either in the latex or in the wet coagulum prior to machining. Rubber latex normally contains a large number of bacteria and other micro-organisms which are capable of acting on the serum constituents of the latex so as to produce changes which result in the formation of minute quantities of gases and in the appearance of bubbles in the prepared sheet. These changes may take place in the latex at any stage of the process from tapping of the trees to the stage which immediately precedes the machining of the wet coagulum, and hence it is essential that there is as little delay as possible in the collection of the latex, its transportation from the field to the factory, and thereafter in the addition of the acid coagulant. Fermentative changes are very liable to occur when the trees are tapped after heavy rainfall, as the latex then becomes infected with bacteria which are washed into it from the bark in the vicinity of the tapping cut, and the extent to which fermentation may take place in a latex depends, among many other factors, upon the locality from which it is obtained, the character of the soil in the locality, the season of the year during which tapping is carried out, the system of tapping followed, and the physiological characters of the tree. On some estates the unexpected appearance of bubbles in sheet which for a long time has been free of them, and the equally unexpected disappearance of the trouble, is not an infrequent occurence.

Methods for the prevention of bubble formation aim at producing in the latex a medium unfavourable to the action of the ferments by the addition of an anti-coagulant substance, in the use of which very satisfactory results have been obtained by the addition of an aqueous solution of sodium sulphite. A stock solution is prepared by dissolving 1 lb. of anhydrous sodium sulphite in 3 gallons of water and is used at the rate of 5 fluid ounces per 4 gallons of latex. This formula applies to its use both in the

field and in the factory. Its use serves a double purpose, as not only is it useful in the inhibition of fermentative changes, but it possesses in addition anti-coagulant properties, and thus makes possible the output of a crop consisting of the maximum amount of first grade rubber and the minimum of coagulated "lump". It cannot be too strongly emphasised that fermentation in a latex may begin very soon after tapping, and if these fermentative changes are allowed to proceed to a sufficiently advanced stage while the latex is in the field, the addition of sodium sulphite in the factory only will not prevent the formation of bubbles. In such cases it must be used in the field as described above, and a little of the anti-coagulant solution must also be poured into the cups and a few drops allowed to run down the tapping cut. The addition of a solution of formalin to the latex serves the same purposes as sodium sulphite and also gives very satisfactory results. In its use, however, precautions have to be taken to ensure that an excess is not added, as otherwise it has a harmful effect on the rubber.

It will be evident from what has been said above that all utensils used for the handling of the latex both in the field and in the factory must be clean, and that a plentiful supply of clean water for factory operations is essential. In this connection it may be pointed out that it is a matter of great difficulty to remove small pieces of coagulated rubber and fermentable serum products which lodge in the fissures of wooden coagulating tanks and partition boards, and this is the basis of one of the arguments which can be advanced in opposition to the use of such tanks. The same remarks apply with equal force to the case of tanks lined with glazed tiles unless the interstices between the tiles are filled in with a suitable cement. Particulars of such cements may be had on application to the Institute. When coagulation is carried out in large tanks it is often found that bubbles occur on only one of the long sides of the sheet. This corresponds to the side of the coagulum which was nearest to the bottom of the tank, and the bubbles are produced as the result of anaerobic fermentation—that is, fermentation which takes place in the absence of air.

In preventing bubble formation care must be taken to use the correct quantity of acid coagulant and to ensure that thorough mixing of the coagulant and latex is effected.

Reference may be made to what are commonly spoken of as "blisters", which are produced as the result of over heating in the smoke-house particularly in the early stages of the smoke-curing process.

3. "Rust".

It is sometimes found that on stretching a piece of smoked sheet rubber and allowing it to recover after stretching, a brownish coloured powder appears on the surface at the part which has been subjected to stretching, while in a few cases the powder may be observed on the surface even before the sheet is stretched. On account of its appearance this powder is commonly spoken of as "rust", and is probably formed as the result of the decomposition by micro-organisms of the serum substances which exude from the sheet after it has been machined. An investigation is at present being carried out by the Institute with a view to the isolation and the identification of the micro-organisms responsible for this decomposition and with the object of establishing the chemical nature of the constituents of the "rust".

It has already been shown that of a batch of sheets prepared on the same day and under the same conditions, those which were stored in a moist atmosphere for a period of two days after machining became covered with a thick coating of "rust", while those of the same batch stored in a moist atmosphere containing a little of the vapour of formalin were entirely free from this defect. This result and others already obtained indicate that the presence of moisture is favourable to the growth of "rust", and that its development may be checked by suitable antiseptic treatment of the freshly machined sheets. The temperature of the atmosphere usually maintained inside a smoke-house is also very favourable to its growth.

In the majority of cases, therefore, methods for the prevention of "rust" aim at rapid surface-drying of the sheet, and hence it is recommended that, after machining, they be hung to drip for about two hours on racks placed in the open air and in a shaded site, after which they should be transferred to the smoke-house, the temperature of which in the initial stages of smoke-curing should be higher than in the final stages. The temperature should be maintained between 110° and 120°F. In more severe cases an antiseptic must be used, and in this connection it has been found that soaking the freshly machined sheets for half an hour in an 0.1 per cent aqueous solution of para-nitrophenol, the treatment being the same as that used for the prevention of moulds, is effective in preventing the formation of "rust". After removal from the bath of para-nitrophenol solution, the sheets are allowed to drip in the open for two hours as outlined above before being transferred to the smoke-house.

B. Crepe.

1. "Spot" Disease.

Pigmented spots in crepe rubber are produced by the growth under suitable conditions of fungi, the spores of which are always present in abundance in freshly machined crepe rubber. These spots may be of different colours,—red, orange, yellow, blue, green, violet, and black—although violet spots are of the most frequent occurrence. As in the case of moulds on sheet rubber these fungi require suitable conditions of temperature and moisture for their development, although in the latter case simpler methods suffice to prevent their growth.

Bearing in mind that only in the presence of air and under favourable conditions of temperature and moisture will the fungi develop, it will be seen that the following factors will promote the production of coloured spots on crepe.

(a) *Delay in transferring the freshly-machined crepe to the drying sheds.*—It is necessary that there be as little delay as possible in this operation, and the crepe should be hung in the drying sheds on the day on which it is machined. The object should be to dry the crepe as quickly as possible in order to produce conditions inimicable to the growth of the organisms at an early stage. Very many cases of "spot" disease have been found to be due to neglect in this direction.

(b) *Inefficient ventilation in the drying sheds.*—Drying sheds are best constructed of corrugated iron which is a good conductor of heat, and the ventilation should be such as to ensure a good upward current of air within the drying chambers.

(c) *Excess of sodium bisulphite.*—In crepe manufacture sodium bisulphite is widely used in order to produce a crepe of pale colour. It is a hygroscopic salt, and if too large a quantity is added to the latex, it will absorb moisture from the atmosphere and retain it on the surface of the crepe.

(d) *Insufficiency of sodium bisulphite.*—Sodium bisulphite has an antiseptic action towards fungi and the correct quantity must be added to the latex before coagulation. The sodium bisulphite should be added at the rate of 1 lb. of the salt dissolved in 10 gallons of cold water to 100 gallons of latex standardised to a rubber content of 1½ lbs. per gallon in the case of pale crepe manufacture, and 2½ lbs. per gallon in the case of sole crepe manufacture.

(e) *Excessive thickness of the crepe.*—A thick crepe contains a higher proportion of moisture than thin crepe, and hence the coagulum should be machined as thinly as is consistent with the production of a crepe of good even texture.

(f) *Storage of the dry crepe under damp conditions.*—Storage in direct contact with a cement floor is frequently a cause of dampness of the finished crepe.

If the recommendations outlined above are followed there is seldom any necessity for further treatment. In special cases, however, an antiseptic substance must be used, an effective method being to soak the freshly machined crepe for half an hour in a bath of formalin of 1 per cent. strength before transferring it to the drying sheds. This treatment is not a sufficient safeguard in itself, and attention must be paid to the other details of manufacture to which reference is made above.

2. Tackiness.

Tackiness or stickiness in first grade rubber is very seldom met with at the present day, whereas a slight stickiness of the surface of lower grade crepes such as "compo" crepe and rather more severe cases of tackiness in "earth scrap" crepes are of frequent occurrence. Rubber which has become tacky is rightly regarded as defective, since tackiness involves changes in the chemical and physical structure of the rubber, which in severe cases are sufficient to affect detrimentally the quality of the rubber after vulcanisation. Such deterioration may be brought about in various ways but it is sufficient here to consider only those which occur in ordinary plantation practice.

In the case of the "earth scrap" and "bark shavings" from which lower grade crepes are manufactured, the rubber before arrival at the factory becomes infected with a large number of micro-organisms which are found in the soil and in the bark of the tree, and which are capable of producing fermentative changes in the rubber resulting in a condition of tackiness of the whole or part, depending on the extent to which these changes have taken place. Moreover, it is known that in the presence of air, exposure to the sun's rays and to heat produces this kind of deterioration, and it is evident that the raw material for the preparation of lower grades is so exposed while it is in the field. Hence, since rubber which is subjected to excessive mastication between the machine rolls is liable to become tacky, it will be appreciated that in dealing with lower grades the extent of the mastication treatment is a very important point indeed, the raw material on arrival at the factory having in the majority of cases already deteriorated to a consider-

able extent. Lower grade crepes should therefore be thicker than crepes of the first grade in order that the rubber may receive as little machining as is consistent with the production of a crepe of good appearance and uniform texture. In addition to the usual battery of crepeing machines, a scrap-washer is essential for the manufacture of these grades, and it is well to collect the raw material from the fields as frequently as possible, to cleanse it thoroughly on arrival at the factory, and, if machining cannot be proceeded with until some time afterwards, to store it under water, which must be changed periodically in order to keep it fresh and to remove dissolved putrescible substances. It is often found that if large piles of "bark shavings" are left standing exposed to the air for a few days the interior of the mass becomes quite hot, and this generation of heat may be sufficient to lead to tackiness in the final product. When practicable, the raw material should be converted to crepe form as soon as possible.

Tackiness may also be brought about by specific chemical agents, the presence of minute quantities of copper in the rubber being sufficient to bring about this deterioration. Contamination with copper is frequently brought about by brass filings carried by oil from worn bearings which accidentally comes in contact with the rubber while it is being machined. Again, acetic acid such as is used for coagulation occasionally contains traces of copper salts, since in the preparation of the acid of commerce it is usual to distil it from copper stills. Even as small a quantity as 0.01 per cent of a copper salt added to latex is sufficient to produce deterioration in the final product.

3. Yellow Crepe.

It is frequently found that the latex from young trees is of a noticeably yellow colour, while a yellow crepe is often produced from latex obtained during the early stages of tapping on a new cut. Again, in the periodic system of tapping the crepe may be yellow in colour for some days, when tapping is commenced after a period of rest. The yellow colour is due to the presence of a naturally occurring vegetable pigment in the latex, and it may be said here that investigations have been carried out by the Institute with the object of identifying this pigment and that the results will be published shortly in Bulletin form.

An increase in the amount of sodium bisulphite added to the latex will not reduce the depth of the colour, but by the usual methods of fractional coagulation adopted in the manufacture of sole crepe, most of the yellowing colouring matter may be removed in the first coagulum, a very pale coloured crepe being obtained from the second fraction.

VEGETATIVE CHARACTERS AND YIELD OF HEVEA.

By A. R. SANDERSON and H. SUTCLIFFE.

The possibility of establishing a close correlation between yield and one or more vegetative characters has been the subject of investigation by quite a large number of workers on Hevea, the final objective being selection of high yielders for propagation purposes.

Whitby (12) from the examination of 1,011 seven years old trees in the Federated Malay States found that the outstanding feature of the population was the high coefficient of variability for yield and the marked positive skewness of the yield frequency curve. He concluded from this that the presence of an important number of trees yielding amounts of rubber several times larger than the modal amount, afforded in proportion to the size of the population, a large mass of material for the profitable exercise of selection.

In the distribution of yield among trees of a normal area of rubber 9.6% of the trees (trees giving double the mean quantity or more) were on the average yielding 3.6 times as much rubber per tree as the remainder of the trees.

He found that the assumption that a tree with a thicker trunk will give a bigger yield than one with a thinner trunk is not a sufficient guide for the selection of trees for thinning out to the extent to which it was in use and that the correlation between girth and yield though positive, did not justify girth being used as the sole criterion for thinning out purposes.

Rutgers (9) concluded that selective thinning must be based on reliable data, that is on the yields of individual trees.

Bobilioff (2) working with 491 trees of mixed parentage investigated the correlation coefficient between the number of rows of latex vessels and yield of dry rubber. He found that the frequency curve for the number of rows was very similar to the one obtained by Whitby for yield, indicating that a large number of trees yielding above average were available as mother trees or for seed selection. He also found there was a coefficient of correlation of $+ 0.55 + 0.051$ between yield and rows of latex vessels in the trees examined.

Heusser (6) experimented with 100 trees grown from the seeds of four vigorous and high-yielding mother trees. He found that the daughter trees showed great variation in yield, although the increase in yield was 16.8% over the old plantings based on equal areas. Based on calculations for individual trees the selected ones gave an increase of 75%. He considers it is desirable in selecting mother trees, that vegetative vigour should go hand in hand with high production. He states, "thinning out trees based on the "number of latex vessel rows does not yield satisfactory results "this is especially true in younger plantings. Thinning out trees "on the basis of tapping tests and yield measurements is preferable".

Gehlsen (5) carried out experiments in which 4 hectares (10 acres) were thinned out according to latex yield and 4 hectares in accordance with bark examination. The planting was 6 and 7 years old at the beginning of the test. The actual yields over the thinned areas showed no difference between the two methods.

La Rue (7) took samples of cortex from 955 trees which were 8 years old the yields being accurately known for more than a year. He concluded that there is beyond question a high correlation between the yield of a tree and the number of latex vessels in the bark. He considers however that this correlation is not high enough to allow the number of latex vessels alone to be used as a criterion in the selection of high-yielding trees.

From 949 trees he found that while the existing correlation is too low for the girth of the trees alone to be used as a factor in thinning, it is high enough to indicate the importance of securing a satisfactory growth increase from year to year. The total results of the correlation, indicate the importance of securing a good growth of the trees throughout the whole period of production.

Bryce and Gadd (4) worked with 161 ten year old trees which were the offspring of Heneratgoda No. 2 tree. From data obtained from these trees, they concluded that there is a decided correlation between the number of latex vessel rows and yield and that the number of latex vessels has a direct influence on the yield, those trees having the larger number of rows normally give greater yields, though they point out that trees with the largest number of rows are not necessarily the highest yielders. In connection with girth and yield they obtained a correlation coefficient of $+ .582 \pm .035$ which is much higher than that obtained by most other workers from more mixed populations. They conclude that there is a closer association of girth and yield in offspring of one mother tree than

there is in mixed populations. As regards girth and number of rows of latex vessels they consider that greater girth is associated with a greater number of latex vessel rows.

Belgrave (1) from experimental work on 106 trees, came to the conclusion that selection by girth measurements can hardly be regarded as satisfactory either for thinning or breeding, and the selection of high-yielders on immature areas by girth measurements to be hazardous.

Taylor (10) continued the work started by Bryce and Gadd on the 161 trees, the offspring of Heneratgoda No. 2 tree and concludes that yield is an inherent quality of the tree and that a latex vessel row count is of more value in connection with thinning out operations with older trees than with very young trees.

FIELD EXPERIMENT No. 1. PATALING ESTATE.

This field experiment described as Field Experiment No. 1 was the first of a series of three inaugurated by the authors with a view to determining to what extent certain vegetative characters could be correlated with yield, and further to find out if any such character or group of characters could be safely used as a criterion for the selection of high-yielding mother trees. In any case it was felt that even if no character apart from yield could be discovered for selection purposes, characters desirable in selected material might be found which influenced the yield of Hevea.

A suitable area for the experiment, planted in 1915 was placed at our disposal by the Directors of the Pataling Rubber Co., Ltd.

On the completion of field Experiment No. 1 in September 1923 a number (21) trees were selected as mother trees. From the selected trees buds were taken and plants budded in a nursery on Sungei Way Estate. The buddings treated as stumps, were planted out on a 12 acre block on Pilmoor Estate, 20′ x 20′ apart, the separate clones being planted as clones in rows.

The experimental area consisted of a portion of Field 49 approximately 500 trees divided into five series, 100 trees in each (A to E). The trees were very uniform in growth planted in 1915 and the ground fairly flat with two shallow depressions liable to temporary flooding during very wet periods. The soil in the main consisted of a fairly light sandy loam, allowing free and quick drainage. The plants were raised from ordinary unselected seed and must be considered genetically heterogeneous.

Cortex Examination.

Plugs of cortex were taken with a $\frac{5}{8}$″ cork borer one each from a large lateral root near the bole, and others at 5″, 10″ and 20″ from ground level from each series except series A, from which in addition plugs were taken at 40″ and not from 5″. Sections were cut from the plugs, stained and examined microscopically to make the latex vessel row count.

Girth Examination.

Girth measurements were taken in September 1922 at 20″ from ground level.

Yield Measurements.

Tapping was opend in October 1922 at 22″ and continued until September 20, 1923, during which period 68 tapping were recorded both volumetrically and by weight. For the latter purpose, the latex was coagulated in the cups, the coagulum rolled and weighed when dry. Cut scrap was included in the coagulum. For volumetric records a manometer specially designed by the authors, was used throughout the experiment. The indicator consisted of a solution of Sudan III in kerosene oil. This liquid moves quickly does not clog in the tube, evaporates slowly, is perfectly transparent, and is not materially affected by changes in atmospheric humidity. It was found that very accurate measurements of volume could be made quickly with this instrument using cups uniform in size and shape. Aluminium cups of standard size and shape were used. Tapping was alternate daily on a basal V opened at 22″ from ground level. The task for each of two tappers was a very small one—some 125 trees—and each tapper changed tasks for each successive tapping. The object of the small task was to complete tapping early, so that volumetric records could be made before coagulation took place to an appreciable extent.

Recording was not always started at the same point. During the progress of the experiment all trees which showed signs of disease or white ant attack, were eliminated from the records.

Latex Vessel Rows Measurements.

In Table I, the numbers of latex vessel rows at different heights are summarised.

TABLE 1.

Differences in Numbers of Latex Vessel Rows at different heights.

	Total latex vessel rows at 5″	Total latex vessel rows at 10″	Total latex vessel rows at 20″	Total latex vessel rows at 40″
Series A. 96 trees ...		1251	1077	904
Averages ...	...	13.0	11.2	9.4
,, B. 94 trees ...	1553	1322	1108	
Averages ...	16.5	14.0	11.8	
,, C. 96 trees ...	1365	1179	976	
Averages ...	14.2	12.3	10.0	
,, D. 99 trees ...	1441	1262	1079	
Averages ...	14.5	12.7	10.9	
,, E. 100 trees ...	1581	1371	1159	
Averages ...	15.8	13.7	11.6	
	Trees	Trees	Trees	Trees
Whole Area ...	389 5940	485 6385	485 5371	96 904
	Average 15.27 at 5″	Average 13.17 at 10″	Average 11.00 at 20″	Average 9.4 at 40″
Differences in average		—2.1	—2.17	

From the foregoing Table I it is evident that throughout the area examined (485 trees) and tapping at 10″ as compared with 20″, assuming the tapping to be approximately equal in depth in the two cases, there is every probability that at each tapping 1014 more latex vessel rows would be opened at 10″ than at 20″ or an increase of 18.8% equal to nearly 1/5. This cannot be looked upon as negligible in its effect on yield at the lower point. Futher, dealing with the 389 trees examined at 5″ also, the difference in the total number of latex vessel rows for these trees at 5″ and 20″ is (5940—4294) = 1646 a difference of 38.3%. The effect of this must be considerable so far as yield of latex is con-

cerned, altogether apart from the result, to be expected, from a constant increase in length of cut as the tapping approaches the base of the panel.

Of 389 trees from which sections of cortex were examined and the latex vessel rows counted at 5″ and 20″—a difference in height of 15″ only—it was found that in only seven trees there was no difference in number of latex vessel rows at the two points.

Table 2 shows the details of differences in number of latex vessel rows at different heights and the number of trees:—

TABLE 2.

Differences in numbers of latex vessel rows.

	No. of trees.	Differences in numbers of latex vessel rows																	
		17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
5″–20″	390		1	–	1	–	2	4	4	11	5	34	29	44	73	77	62	36	7
5″–10″	390						1	1	–	1	3	7	7	18	27	61	92	97	75
10″–20″	390					1	–	–	–	1	2	4	10	16	25	70	96	110	55

In the mixed population of 485 trees examined one type only can be distinguished, i.e., trees with more latex vessel rows at points nearer ground level than at points more distant from ground level.

Of the 390 trees (B to E) 65.4 per cent show a difference of 4 rows or less between 5″ and 20″.

No conclusions can be drawn from these figures as regards the selection of a high yielding type of tree.

There is not sufficient evidence to show that for the particular age class a high yielding type of tree must have a difference of more than four latex vessel rows between 5″ and 20″ from the collar. It must be pointed out however that the experiment was not continued to the base of the panel but only until approximately one third was tapped off.

The whole of the trees were grouped:—

(a) according to number of latex vessel rows at 20″.

(b) according to girth at 20″.

At 20″ the number of latex vessel rows varied between 4 and 20 the great majority falling round the mean—11.

Correlation of Girth and Latex Vessel Rows.

It is significant that for each average girth increase of 4″ at 20″ there is an average increase of one in number of latex vessel rows, i.e., there is a relationship between the girth measurement at 20″ and the number of latex vessel rows at that point.

The correlation coefficient between the characters girth and number of latex vessel rows is +.44 +.036. This is sufficiently high to indicate a definite correlation but not high enough to be conclusive, i.e., in comparing trees of equal age under the same or similar conditions, the assumption is not justified that trees of greatest girth at 20″ will also have the largest number of latex vessel rows at that point (see Table 3).

TABLE 3.

Number of latex vessel rows and girth at 20″.

Mean number of latex vessel rows at 20″	= 11. 0 ±. 13
Mean girth at 20″	= 34. 4 ±. 26
Standard deviation: latex vessel rows	= 2.86 ±. 09
Standard deviation: girth	= 5.81 ±. 18
Correlation coefficient	= +.44 ±.036
Number of trees	=493

Correlation of Yield and Girth at 20″.

The correlation coefficient obtained is +.52 +.033 the partial correlation being +.3983. The partial correlation coefficient is the figure obtained for two characters in the presence of three or more, eliminating the influence of the other characters concerned. e.g., the three characters concerned all variable, are girth, number of latex vessel rows and yield.

Since both girth and number of latex vessel rows influence yield the correlation coefficient between girth and yield, or between number of latex vessel rows and yield obtained in the ordinary way, cannot give a true appreciation of the value of the one character girth, or latex vessel rows in connexion with yield. By calculating the partial correlation the influence of the third character is eliminated i.e., it is calculated on the basis of the third or more characters becoming constant instead of variable. This figure (+.3983) is too low to justify selection of a small percentage of high-yielding trees by girth measurement alone, but yet is sufficiently high to indicate that large girth is a desirable character, since it has some influence on yield.

In connection with this Heusser (6) states that in selecting mother trees vegetative vigour should go hand in hand with high production, and La Rue (7) emphasizes the importance of obtaining a satisfactory growth increase from year to year (see Table 4.)

TABLE 4.

YIELD AND GIRTH AT 20″.

Average yield per tree per tapping in grams dry rubber (68 tappings).

Mean yield	= 10. 0 +. 25
Mean girth	= 34. 4 +. 26
Standard diviation yield	= 5.65 +. 18
Standard deviation girth	= 3.81 +. 18
Correlation coefficient	= +.52 +.033
Number of trees	=493

YIELD AND NUMBER OF LATEX VESSEL ROWS AT 20″.

The correlation coefficient between the yield and latex vessel rows at 20″ is +.46 +.036 and eliminating the character girth the partial correlation is +.2265. In neither case is this figure sufficiently high to justify selection by the latex vessel rows count alone, but indicates that a large number of latex vessel rows is a desirable character and has considerable influence on yield (see Table 5).

TABLE 5.

YIELD AND LATEX VESSEL ROWS AT 20″.

Yield per tree per tapping in grams dry rubber.

Mean yield	= 10. 0 +. 25
Mean number of latex vessel rows	= 11. 0 +. 13
Standard deviation yield	= 5.65 +. 18
Standard deviation latex vessel rows	= 2.86 +. 09
Correlation coefficient	= +.46 +.036
Number of trees	=493

It may be noted here that in making the count of latex vessel rows two possible sources of error may be introduced.

(1) The whole of the latex vessel rows from the sclerenchyma ring to the cambium are included, but not all of these are opened during ordinary tapping, the number left unopened being a variable one depending on the depth of tapping.

(2) Some latex vessel rows towards the outer limits of the cortex contain latex vessels which have already degenerated and the latex cannot be withdrawn in tapping. This number is also a very variable one.

(3) Some trees show a much greater number of radial connections between the separate latex vessel rows than others. This may have some bearing on results obtained, although no definite data appears to have been worked out.

Vischer (11) states however, "Radial connections between the different latex vessel cylinders are very infrequent and are of little value".

The extent of the possible effect of making a latex vessel row count, eliminating those not opened in tapping is shown, in Tables 7—10. These tables deal with trees in the 2nd field experiment on Sungei Way Estate 1923—1924.

The following tables 7 to 10 show the value of the possible error in correlation between yield and number of latex vessel rows, due to the count including all the latex vessel rows present in the cortex, i.e. the inclusion of latex vessel rows which are not opened in the ordinary course of tapping. The assumption is made that 1.1 mm. thickness of cortex is left uncut during tapping. For the 200 trees tested the results show that the error introduced is small in effect.

TABLE 7.

SERIES A.

Table showing number of latex vessel rows present in the first 1.1 mm. of cortex from the cambium.

Number of latex vessel rows in first 1.1 mm. of cortex.	Number of trees.	Average number of tota latex vessel rows in cortex.
2	12	12.5
3	29	13.2
4	37	14.0
5	12	15.0
6	7	15.8
7	2	20.0
8	1	17.0
	100	

TABLE 8.

Series B.

Table showing number of latex vessel rows present in the first 1.1 mm. of cortex from the cambium.

Number of latex vessel rows in the innermost 1.1 mm. of cortex.	Number of trees	Average number of total latex vessel rows in cortex.
2	2	9
3	17	11
4	28	13.7
5	30	14.7
6	15	16.1
7	6	20
8	2	24.5
	100	

TABLE 9.

Series A.

Correlation between yield and latex vessel rows.

	Latex vessel rows excluding those present in the innermost 1. 1 mm. of cortex.		Full number of latex vessel rows.	
Mean yield	= 4.20	±.165	= 4.20	±.165
Standard deviation yield	= 1.65	±.116	= 1.65	±.116
Mean number of latex vessel rows	= 10.03	±.256	= 13.86	±.139
Standard deviation latex vessel rows	= 2.56	±.181	= 2.88	±.203
Correlation coefficient	= ±455	±.079	= ±.423	±.067
Number of Trees	= 100			

TABLE 10.

Series B.

Correlation between yield and latex vessel rows.

Latex vessel rows non-inclusive of those present in the innermost 1.1 mm. of cortex.			Full number of latex vessel rows.	
Mean Yield	= 4.33	±.20	= 4.33	±.20
Standard deviation Yield	= 2.03	±.14	= 2.03	±.14
Mean number latex vessel rows	= 9.85	±.34	= 14.5	±.394
Standard deviation latex vessel rows	= 3.40	±.24	= 3.94	±.27
Correlation coefficent	= +.40	+.084	= +.365	±.087
Number of trees	= 100		= 100	

Percentage Dry Rubber Content of Latex.

The accompanying table No. 11 shows the results of determination of dry rubber content of latex. The figures have been obtained from the total yield of latex for 68 tappings spread over 12 months against the weight of dry rubber.

A glance at the table shows that in Series A & E the dry rubber content on average is considerably lower than for Series C, D & E. The difference is probably due in large part to the fact that in October and November 1922 and again in April and May 1923, portions of these areas were subject to severe flooding for several days at a time. The number of trees yielding on average latex with a dry rubber content of less than 2½ lbs. per gallon is surprisingly large.

It should be noted that the opposite end of the table may be influenced to some extent by the amount of cut scrap, the weight of which is included in the dry rubber weights.

A number of trees of which the volume of latex could not be accurately measured, owing to rapid coagulation in the cups, are excluded from the records.

The coefficient of variability 14.6 is so high that volumetric determination of yield alone could not be relied on to select a small percentage of trees as mother trees. Final determination of yield should be by actual dry rubber.

TABLE 11.

FIELD EXPERIMENT No. 1.

Percentage dry rubber content of latex.

Series	16-20%	20-22%	22-24%	24-26%	26-28%	28-30%	30-32%	32-34%	34-36%	36-38%	No. of Trees
A	7	10	11	17	22	19	4	4	1	--	95
B	—	2	2	7	18	18	17	12	8	4	88
C	1	1	6	12	18	18	16	11	6	3	92
D	1	—	5	10	9	25	24	16	6	1	97
E	5	8	17	27	22	8	7	2	2	—	98
	14	21	41	73	89	88	68	45	23	8	470

Extreme variation = 22%
Coefficient of variability = 14.6%

TABLE 12.

Details of Trees Selected as Mother Trees.

No.	Tree No.	Number of Latex Vessel Rows at :— 5″	10″	20″	Girth at 20″	Average yield per tapping for for 68 Tappings in Grams yield per dry rubber.	Average percentage dry rubber content for 68 Tappings over a period of 12 months.
1	B.58.	15	14	11	44	42.3	27.0
2	A.44.	...	14	12	42	42.1	31.4
3	C.72.	21	19	14	47	34.8	30.9
4	B.84.	27	21	20	41	28.7	26.8
5	A. 8.	...	18	17	41	28.2	26.0
6	B.90.	20	17	16	43	27.3	22.7
7	D.61.	24	19	17	43	26.3 (a)	25.0
8	D.38.	20	20	18	46	25.8	35.9
9	B.65.	13	11	10	33	25.3	27.4
10	D.29.	20	19	17	36	25.1	26.1
11	E.95.	31	27	20	42	24.5	30.0
12	B.16.	13	10	9	37	24.3	28.1
13	A.11.	...	15	12	44	24.1	31.1
14	E.41.	24	24	19	44	23.6	30.1
15	B.50.	32	20	18	40	22.8	22.9
16	B.95.	26	22	22	45	22.8	28.3
17	C.94.	17	14	11	45	21.5	24.6
18	E.43.	19	16	13	38	20.4	23.8
19	D.65.	15	13	10	33	17.7	24.0
20	A.87.	...	35	22	45	12.2 (b)	32.4
21	B.11.	26	21	17	44	10.1 (b)	35.2

Selection of High Yielders.

At the end of the year's tapping 21 trees were selected to be used as mother trees for vegetative propagation details of these are given in Table 12. In the great majority of cases the selection was made primarily on a yield basis, but anatomical characters of the cortex and girth were also given due consideration e.g.,

only two of the selected trees are of less than average girth and only one contains less than the average number of latex vessel rows.

Eleven of the selected trees had an average dry rubber content less than that (27.89%) for the whole block. Of these eleven, two viz. B. 90 and B. 50, showed a very low average percentage of dry rubber viz. 22.7% and 22.9% respectively.

(a) D. 61 was chosen as a Brown Bast tree to see the results of budding from it.

(b) A. 87 and B. 11 were picked as poor or very moderate yielders but with anatomical characters and girth comparable to the best.

B. 11 and B. 58 are equal in girth but the former has a much greater number of latex vessel rows, yet the yield ratio is 1 to 4. Again B. 16 and B. 11 have a latex vessel row ratio of 1 to 2 and a yield ratio of 2 to 1.

It should be noted in connexion with the preceding table that the figures are slightly too high, since the dry rubber includes the cut scrap. This error will be greatest in general in the case of the lowest yielders.

COEFFICIENTS FOUND BY OTHER AUTHORS.

WHITBY, G. S.
Girth and yield (dry rubber) ... + .260 ± .02

RIJKS, A. B.
Latex vessel rows and yield (latex) ... + .51

BOBILIOFF, W.
Latex vessel rows and yield (dry rubber) ... + .55 + .051

HEUSSER, C.
Latex vessel rows and yield (dry rubber) 4 year old trees ... + .426 ± .082
Latex vessel rows and yield (dry rubber) 5 year old trees ... + .535 ± .071
Latex vessel rows and yield (dry rubber) 6 year old trees ... + .536 + .071
Girth and yield (dry rubber) ... + .326 ± .067
Yield (dry rubber 4th and 6th year) ... + .641 ± .059

GEHLSEN, C. A.
Latex vessel rows and yield (latex) 1920/1921 ... + .585 + .028
Latex vessel rows and yield (latex) 1920/1921 ... + .589 ± .027
Latex vessel rows and yield (latex) 15 year old trees ... + .578 ± .083

LaRue, C. D.		
Latex vessel rows and yield (dry rubber)	...	+ .513 ± .016
Girth and yield (dry rubber)	...	+ .299 ± .019
Latex vessel rows and girth (dry rubber)	...	+ .162 ± .021
Bryce & Gadd.		
Latex vessel rows and yield (dry rubber)	...	+ .459 ± .042
Latex vessel rows and girth (dry rubber)	...	+ .399 ± .046
Girth and yield (dry rubber)	...	+ .582 ± .035
Belgrave, W. N. C.		
Girth and yield Plot A. (dry rubber)	...	+ . 39 ± . 08
Girth and yield Plot F. (dry rubber)	...	+ . 55 ± . 06
Taylor, R. A.		
Yield and yield (dry rubber) 1922/23, 1923/24		+ .834 ± . 06
1923/24, 1924/25		+ .735 ± .025
Yield and girth (dry rubber) 1923/24, 1924	...	+ .378 ± .046
Yield and girth (dry rubber) 1924/25, 1925	...	+ .408 ± .045
Yield and latex vessel rows 1924/25, 1925	...	+ .574 ± .037

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THE SOUTH AMERICAN LEAF BLIGHT AND DISEASE RESISTANT RUBBER.

By J. R. WEIR.

The history of many plant diseases that have become epidemic shows that those which have been most destructive or most difficult of eradication or control, are those which have been introduced from other countries. This may be due to several factors. The original host may occur in greater quantity in the new locality, a new and more susceptible host may be present, or it may occur in pure stands thus enabling the disease to spread more rapidly and become more thoroughly established, and finally the climate may be more favourable to the production and dissemination of reproductive bodies and infection.

With this introduction it is proposed to warn the rubber planting community of Malaya against the one leaf disease of Hevea which in all likelihood if introduced into Malaya and the East would cause as profound a change in agricultural economics as did the coffee leaf disease in Ceylon.

The disease referred to is the South American Leaf Blight and the casual fungus is *Dothidella Ulei*. The fungus is apparently coincident with the natural range of Hevea in South America. It occurs in Trinidad which is the only known extension of the parasite outside the mainland. The fungus is an obligate parasite and is highly specialized on Hevea. No other host is known. Although the life history of the fungus includes three distinct spore forms it is the first or the conidial stage which is largely responsible for the rapid spread of the disease. Young leaves as they unfold are rapidly parasitised and trees of all ages become entirely defoliated. The second crop of leaves is infected and the process goes on until the twigs and branches are depleted of food material and either die or fall a prey to various secondary fungi which hasten the death of the tree. In Dutch Guiana where the fungus caused a cessation of rubber planting three successive defoliations in a period of six months took place. The fungus also attacks the inflorescence, young twigs, and fruits. The immature pods are afterwards attacked by Diplodia, Gloeosporium and other fungi and their contents become black and shrunken. The writer found trees on the Amazon showing an infection of the pods of

more than 60 per cent. The worst feature of the infections on the young branches and pods is that the fungus is held in a condition making new infection on young leaves readily possible.

Conditions in Malaya Favourable to the Fungus.

The fungus causes little or no damage to wild rubber in the Amazon Valley. The density of the natural jungle is a factor in this connection. It is only when a species is established in pure stands that the conditions for the propagation of a parasitic fungus to which the species is susceptible are greatly intensified. Another factor which retards the development of the fungus in Brazil is the rather distinct dry season of some six months during which time rain may not fall for two or three months at a time. The 1926 report of the plant pathologist for British Guiana states that the activities of the fungus were very evenly checked by dry weather especially on inland estates which have long been abandoned on account of the injuries caused by its normal prevalence.

The existing conditions in Malaya are quite the reverse from those in Brazil. There is practically a continuous body of rubber throughout the entire length of the Peninsula and temperature and moisture conditions are fairly uniform. Experience teaches that the virulence of a plant parasite or rather the conditions of infection may be greatly intensified by a favourable climate. This means that when there is a uniform temperature and moisture relationship there is a more abundant production of spores and early stages of development by the parasite as regards establishing relations with its host. Under these conditions there is also a more uniform development of susceptible tissue.

Under the circumstances it is to the interest of the rubber planting industry in Malaya to guard against the introduction of the fungus. Any attempt to introduce promising races of rubber from Tropical America should be entrusted to thoroughly competent investigators. Propagating materials can be brought in disease free but it should be done under the direction and supervision of the authorities controlling such work.

Desirable Types of Rubber in South America.

One does not study *Hevea brasiliensis* in its native home very long before he is impressed with the great botanical variation of the species, especially with regard to those characters which if utilized in selection and breeding work would in all probability

be of great importance to the industry. Out of some thirteen species of Hevea described from S. America there are a few readily distinguishable, and one in particular that has certain leaf characters showing resistance to the South American Leaf Blight. In general, however, the great majority of trees encountered along the Amazon and southward are variations of the one common species. It is from this group that a careful study of forms and types would probably produce a tree of the highest possible value both from the standpoint of yield and of resistance to the Blight. The study of these forms particularly those in the upper Amazon has never been successfully carried out. It is a subject worthy of being on the roster of investigations by the industry.

Disease-Resistant Rubber.

The improvement of rubber from a yield standpoint has been so industriously followed during the past few years that the problem of disease resistance and immunity in the tree has been almost entirely neglected. The existence of natural types or forms of wild rubber has been indicated. It has also been observed that certain of these forms and species exhibited a natural resistance to disease to a certain degree. In the Guianas, observers have called attention to the existence of apparently immune trees in all plantations affected by the leaf blight. Such a condition in the latter case could scarcely be attributed to accident in spore dissemination, or failure of the trees to produce leaves at the same time. Individual seedlings in our nurseries are occasionally observed to exhibit a high degree of resistance to the Helminthosporium leaf blight. In India rubber trees resistant to leaf fall have been noted. Some observations in Ceylon indicate natural immunity of rubber trees to bark rot. These observations point the way. The relative liability of varieties and species to disease has been known since early times. Remarkable results have been obtained in several horticultural, field and garden crops. These results however are of comparatively recent development. The results obtained are of such a hopeful character that the possibility of placing the study of disease resistance on a scientific and practical basis may be expected. This is abundantly illustrated by the work that has been done in developing resistance in plants against various soil organisms. The old idea of soil being "sick" to certain crops has been largely exploded. In many cases of this kind they have been found to resolve themselves into disease situations, with definite causal factors separate and apart from any toxic action which any crops may have on succeeding crops of the same kind. These so called "sick soils" have been found to be infested with various

wilt and rootknot organisms. With the development of resistant varieties it has been found that these troubles can be controlled to a large extent at will. The breeding and selection of plants for local adaptation and disease resistance is the most important future line of work in the control of many plant diseases. The problem of what constitutes disease resistance and the difficulty of defining the factors involved should not prevent the expenditure of energy in promoting the development of disease-resistance in rubber.

The search for trees exhibiting resistance to disease is being made. It is also proposed to establish a special test garden for the accumulation and intensification of local pathogens in soil and trees for the purpose of emphasizing "the survival of the fittest" through elimination of non-resistant individuals. It will be desirable to bring to this garden Hevea Guyanensis, H. Spruceana, H. Collima, H. Benthamiana and other species for the purpose of studying the quality of their root systems and vigor of growth in relation to infection and resistance. Other methods of work are planned.

The factors involved in beginning work on a previously uninvestigated plant such as the rubber tree are extremely varied and range through all the methods of selection by seeds and vegetative propagation and of studies in parasitism. A few fundamental considerations may be briefly mentioned.

From the standpoint of the organisms against which we direct our efforts there are two main classes. There are those which feed upon dead parts of the tree only becoming pathogenic under certain conditions and those which directly attack or affect the living cell.

These being the natural enemies of plants and responding to the same factors of growth it is reasonable to assume that there has been a struggle going on between plants and their enemies both animal and vegetable. The weaker individuals in the forest yielded to their attacks while the strong and vigorous did not and in conformity with a general law of nature gradually developed characteristics or qualities that enabled them to withstand attack. This naturally did not take place in a short time for such changes in the nature of a wild plant may require ages to develop. It is the work of the plant pathologist to seize upon the most desirable characters which bear upon his problems and attempt to hasten or fix the most desirable feature already initiated in nature. He will begin by observing some simple natural phenomena.

Temporary Immunity.

It is not uncommon to observe that leaf age or leaf growth is a factor in susceptibility to any particular disease. This gradual development of resistance or immunity is very striking and important when considered from the standpoint of amount of inoculum (i.e. quantity of infection), elevation and climate. It often happens that a dry season as previously indicated prevents the development of the particular spore responsible for infection of young leaves. In the meantime the leaves of the susceptible plants continue to develop and reach that stage which owing either to a change in the materials available as food for the early nutrition of the fungus or to certain changes in the thickness and composition of cell walls, leaf covering etc. and which may be classed as physical are no longer susceptible to infection.

Striking examples of this condition are found in the secondary leaf falls with which fungi are associated and more especially in the South American Leaf Blight.

In conditions like the above the opportunity is afforded to observe the effects of rapid growth, physical peculiarities of leaves, site requirements of individual trees looking toward selection and propagation.

Varying Individual Susceptibility Within a Species.

Careful observation will show that all individuals of a species are not equally subject to disease. This observation can be made in many directions among plants as well as among animals and the human species. The conditions of susceptibility to infection varies not only with the individual but also with the infection itself. For example a certain few diseases of rubber secure an almost universal dissemination while others, the effects of which after they become established may be equally or even more severe, affect far fewer individuals. The latter condition dealing with the problem of different types of parasitism greatly extends the scope of the search for resistant forms. The cytologic and physiologic forces which govern a parasitic reaction are but poorly understood, nevertheless constant observations will result in many practical applications. The isolation of individuals of a species exhibiting apparent immunity is a preliminary step. Several theories have been advanced to account for this phenomenon. Observation has led to the belief that in some cases the condition is a direct result of previous heavy infection without destruction. Naturally when a plant has been severely diseased for several

successive seasons its growth is greatly inhibited and the opportunity for infection would be proportionally reduced. This eventually results in a certain degree of resistance being set up in the plant. The process by which individual rubber trees have built up a certain degree of resistance against the South American Leaf Blight may have resulted from a constant struggle with the disease. There is a probability that naturally resistant strains of chestnut may result from the devastation of the North American chestnut forests by the bark canker fungus.

Varying Racial Susceptibility.

It is of the greatest significance that in both plants and animals there is often a marked racial distinction as regards disease. Certain races or strains of oaks are resistant to diseases which attack all other species. Most of all races of wheat are subject to the ravages of the rust fungi of one kind or another, while certain other races are highly resistant. Examples of this racial distinction could be multiplied. Complete immunity is known in but few cases. There are certain races of potatoes which exhibit complete resistance to Wart Disease.

As to the nature of disease resistance it has been shown that genetically considered, in certain plants at least, it is closely associated with the plant metabolism and growth. In such a case the phenomenon becomes a matter of chemical constitution which may determine the difference in disease behaviour. In some instances it is the presence of a toxic substance in the coloured tissues of the host which prevents infection. In races of the same plant devoid of this coloring matter no such substance is present and infection is possible. The nature of resistance will probably be found to vary considerably with each particular race or group.

The actual conditions of inheritance of resistance characters are very little known. In one particular class of parasitism it has been shown that resistance may be regarded as a unit character behaving in crosses of resistant and non-resistant races as a Mendelian unit character.

The foregoing is intended to show the benefits which may be derived from this field of activity. In economic saving and ease of application in those cases where mechanical or cultural methods have failed to produce the desired effect the production of resistance or immunity is most attractive. The knowledge that a certain strain or race of plants is resistant against any particular disease of importance would do away with many of the present

day practices in disease control. It should not be forgotten however that resistance is only one of the many important characters sought in Hevea. The necessity of combining resistance with a high quantity and quality production character is obvious, especially since some lines of budded rubber show a decided weakness in the former respect.

In conclusion it is safe to assume that the only way to successfully combat such a disease as the South American Leaf Blight is through the development of resistant types and this holds true for Brown Bast as well. The selection of high-yielding strain of Hevea resistant to Brown Bast has already been shown to be a promising line of investigation.

Note.—In the interests of experimental work on disease resistance in rubber the co-operation of the planting community is solicited in the discovery of individual seedlings and trees showing an apparent resistance to disease.

Individual seedlings in the nursery may exhibit comparative immunity from Helminthosporium leaf disease.

Individual mature trees may be found showing an apparent resistance to secondary leaf-fall, due to mites or fungi and root and collar rots.

This apparent resistance may be observed in connection with particular soil types, high yielding trees, etc. and the relation should be noted.

Communications on the above subject are greatly desired.

MANURING OF RUBBER.
I.—GENERAL ASPECTS OF THE PROBLEM

By W. B. HAINES.

Recent years have seen a very marked growth of interest in the possibilities of applying artificial fertilisers to rubber. The turning of attention in this direction is the inevitable outcome of the increasing age of estates, revealing ever more clearly those planting sites which have unsatisfactory features, but it is possible that the main impetus to interest has been the reports of remarkable results from manuring in particular cases. That these are rather exceptional has already been shown by more disappointing results in many other cases, but the balance of opinion among those of experience seems to be rather in favour of manuring than against it. Only a small proportion of the trials made have been conducted on a satisfactory comparative basis and until this is done the belief in the efficacy of manuring cannot rest on a scientific basis. This state of the subject leaves a good deal of confusion due to basing arguments upon experience with other crops, so that it is necessary to point out at the outset the sharp contrasts which exist between the case of rubber and that of the other crops for which experience of manuring is extensive and exact.

Comparing the cycle of plant nutrition and growth of an ordinary arable crop and that of a rubber estate it becomes at once evident that the differences are fundamental. In the first case the growth cycle is usually completed within the year, and a very large proportion of the total growth made is removed entirely from the farm. Hence there is a continual extraction and removal of plant nutrients from the soil, and an inevitable tendency towards soil exhaustion. This is offset by the yearly opportunity when the land is clear to effect amelioration by means of cultivation and manuring. In the case of rubber the plant growth is a slow cumulative one with such a small amount of plant nutrients removed in the latex crop as to be almost negligible. Under proper conditions the leaf-fall goes back into the soil, so that the cycle of changes takes place without any great loss. By neglect of conservation the losses on rubber estates have, of course, often been serious, but it is apparent that there is no such inevitability about the approach to soil exhaustion as there is in the case of arable cultivation. This would lead one to expect that the

application of manuring practice to rubber would have a more limited scope.

Another consideration which would tend to instil a cautious approach to the subject is the much less direct connection which exists between nutrition and yield. The aim usually pursued in manuring is a heavier production of fruit or of vegetative growth and more is understood regarding these than regarding the responses involved in increased latex secretion. By far the largest differences to be observed in yield are to be attributed to inherent character. Hence the most promising methods for increasing the acreage yield are those which will provide trees of high yielding character. The fulfilment of such methods, however, must take much time, so that manuring must be examined in all its possibilities as a method of improving the existing stands of rubber. While general improvement can usually be effected (as regards appearance of foliage for example) we as yet know little regarding specific effects upon latex production. With the advancement of knowledge, however, the possibility is not to be overlooked that a connection will be found between some phase of nutrition and the quantity of latex produced. At present nitrogenous manuring, (as being productive generally of sappy vegetative growth) is the most promising, but evidence is not wanting of more specific effects upon latex production of the kind indicated.

There is a third consideration which must qualify the expectation of great improvements from manuring in some cases. In cases where the site has always been poor and the trees have been stunted for many years it may well be asked whether a sufficiently favourable response to manuring may be looked for. There must always be some hope for a tree not actually diseased, but successful manuring must look for vigor in the tree and satisfactory conditions as regards moisture supply and similar matters. Too often a piece of rubber has been selected for a manuring trial on the assumption that the worse the rubber the more the room for improvement. To select the best opportunity for improvement would often lead to more encouraging results. Even on comparatively good sites the fertility of the soil may lag far behind the other abundant conditions of light, heat and moisture. In such a case manuring improves the one limiting factor and produces a benefit, while in more adverse cases other limiting factors may be present to prevent any response. The above considerations are applied to the general prospect of increasing estate yields by extensive use of fertilisers. The value of manures for special purposes should need no emphasising. Much may be done towards the improvement of nurseries and the establishment of cover crops

by judicious use of fertilisers on the lines of well-established practice. By applications made at the time of planting out rubber a healthy and uniform growth can often be ensured and the young trees pulled through their more critical early stages when adverse conditions of weather may catch them at a disadvantage. The cost of manuring in such a case is very small since only the planting holes need to be treated.

The economic valuation of results from manuring rubber will present considerable difficulties. Apart from those attending the fluctuating market values of rubber it will take long periods to assess properly the full effect of a single application of manures, whether as regards increased yields or increased capital value in growth of the trees and in bark renewal. Experiments with annual crops give their end result within the season, but effects on rubber are likely to take many such cycles to work themselves out. Further there is the probable lengthening of the economic life of the trees to be taken into account. Until we are in a position to estimate the benefit on all these points the economics of the problem must remain somewhat indefinite. In some cases the immediate return from manuring has repaid the cost, but it is obviously inadequate to pass judgement on the basis of returns over a short time.

The long periods during which experiments must run calls special attention to the necessity of laying them down with great care and foresight. In recent years the subject of field experimentation has been much developed and the guiding principles laid down. The potential value of the results from test plots may often be increased many times by changes in the layout which involve no extra expense and very little extra demands upon time and trouble. The questions involved will form the subject of the next article. Since all types of soil and situation need to be covered in order to provide full data, the desired end can only be attained by experiments scattered over many estates, and all those who have rubber likely to be benefited by manuring should be encouraged to make trials. The management is then sure of getting such results as are applicable to the particular conditions of the estate, while at the same time contributing to the common stock of knowledge.

NOTES ON A TEST OF METHODS OF PACKING BUDWOOD

By F. BILLINGTON.

I.—Introduction.

The question of suitable methods of packing budwood is one likely to be of importance for some time to come. At present the chief sources of high yielding plant material are outside this country and the supply to other rubber growing countries of this material involves transhipment and journeys of any duration between three days and three weeks. Moreover companies may reasonably expect to be able to estimate the proportion of successful buddings they will probably obtain after a journey of a given duration and the management of estates should be in a position to apportion responsibility for failures between budwood and operators.

That much remains to be done in finding better packing methods is clear from the many complaints that arise from all sides of lack of success after a journey. The progress report of the Peradeniya Experiment Station, Ceylon, for May and June 1928 provides an official instance of the unsatisfactory position at the moment. In this case a consignment of budwood from proved mother trees was received from a Java estate but the wood arrived in very bad condition and no successes were obtained. Another consignment was received from F.M.S. Most of this was also in a bad state, but out of 266 buds put on, 29 successes were recorded at the first examination.

II. Previous Work.

The most thorough study of the question published so far is that of Maas (1), a resumé of which, together with some further ideas and modifications, is given by Summers (2) from whom the following summary is taken:—

The object of any packing method is to surround the sticks with a layer of moist material which will remain so for days and thus check the loss from the surface. As soon as it is cut the budwood is sent directly to the packing shed where it is stood upright with its lower ends in water. Immediately before pack-

ing, the two ends of each stick are wiped, trimmed and dipped into melted budding wax. The sticks are then tied tightly together in bundles of five or six.

A. For short journeys the sticks are next wrapped round with plantain leaf sheaths in such a way that the ends also are completely closed in. When this is done a second wrapping of the same material is put round the whole bundle. From 6 to 10 bundles are tied together and placed in a strong wooden box, the space between them and the sides of the box being filled with perfectly dry sawdust. Rolling the bundles in sacking before placing them in the box gives them additional protection. The budwood should fit tightly in the box to prevent rubbing of stick upon stick.

Instead of dry sawdust as a filling material, coconut fibre slightly moistened may be used, but never wet sawdust.

B. For longer journeys of, say, 7 days sticks are made into small bundles as before and each bundle wrapped separately in sacking before being placed in the box. The space between the bundles and the sides is then filled with moist powdered charcoal; lumps of charcoal should be kept out as being liable to damage bark and buds by rubbing.

A modification of this latter method is to lay a roll of dry sacking on the floor, place a stick upon the end of the sacking and roll a turn or two of sacking round the stick; take the next stick, lay it beside the first and make another turn or two with the sacking; lay a third stick beside the two already wrapped, make another turn or two with the sacking, and so on until a bundle of five or six sticks has been formed, every stick being separated by sacking from every other stick. The bundle is then wrapped in damp sacking and finished off with a turn or two of dry sacking. When wrapped, the bundle is tied with cord and placed in the box with a filling of damp powdered charcoal as before. To prevent the charcoal getting through the sacking, a layer of newspaper can be placed between them.

III. Preliminary Arrangements.

In August of the present year the following experiment was undertaken at the request of the Rubber Estates Agency Ltd., to determine the relative values of different methods of packing. The budwood was supplied by the Eastern Sumatra Rubber Estates Ltd., through the Anglo-Dutch Estates Agency Ltd., of

Medan and S.I.P.E.F. Ltd., of Kuala Lumpur. Arrangements were made for the budding to be carried out on Effingham Estate with the assistance of the Manager, Mr. L. G. Hunt, who kindly afforded us every facility and the benefit of his valuable experience. The thanks of the writer are due to all concerned in the experiment which through their enthusiasm and co-operation went without a hitch.

The budwood was cut between 6 a.m. and 8 a.m. on the morning of the 21st August 1928, and sent by train from Siantar that afternoon. It left Belawan next day for Penang and, having come down by the night mail train, reached Kuala Lumpur on the morning of the 24th: here it was met, brought up to Effingham Estate, and opened at once.

On being opened the boxes were found to contain, as arranged, 120 metres of budwood, being equal quantities of 4 different AVROS clones, each clone being packed by each of the three methods, so that there were 10 metres of each clone packed in each way. Of each 10 metres, five were green wood and five were brown wood.

The three different methods adopted are referred to as fibre, banana and charcoal.

(1) *FIBRE.* The sticks were found in layers lying on coconut fibre, with coconut fibre in between and above each layer. There was no fibre at the sides of the case to prevent the sticks rubbing against the boards.

(2) *BANANA.* Each group of 5 sticks was wrapped in a banana sheath and the sheath securely tied with string, the bundles so formed being buried in dry sawdust.

(3) *CHARCOAL.* Each stick was wrapped in dry sacking and tied with string; each group of 5 sticks was rolled in a further piece of dry sacking, and tied and buried in damp charcoal, which, however, felt dry to the touch. The charcoal had been shaken down in transit, so that a hollow space of about 9″ x 4″ had appeared at one end of the box. To wrap each stick in a separate piece of sacking and to tie it with string in several places is more thorough than we had intended. To roll the sticks in sacking as described above appears to be quite sufficient and very much quicker.

After inspection of the various packings, the sticks were unpacked and the lower, waxed ends sawn off; the sawn sticks were

wrapped bundle by bundle in damped sacking and kept clone by clone and packing by packing in 2 inches of water in latex buckets and stored until required in a cool airy schoolroom with an attap roof. Each stick was found to be properly waxed and clearly and securely labelled with its clone number.

There was no sign of mould on any stick.

IV. Budding.

The four clones received were numbers 49, 50, 80 and 163. Clones were budded in numerical order in a nursery planted in beds containing 10 rows of 25 seedlings planted at about 2′ x 2′. Each clone was allotted three beds, one for each method of packing. Five budders were employed so that each budder had one brown stick and one green stick for each clone and each method of packing. Of these budders, two were R.R.I. conductors of proved ability; the other three were drawn from the estate and had done but little budding for the previous 12 months.

Budding was started directly after unpacking had been completed. Clones 49 and 50 were budded in the order fibre, banana, charcoal; for the other two clones, 80 and 163, the order was reversed. This change of order produced no noticeable effect upon the results.

Clone 49, the first to be used, was not finished that day (August 24th) owing to weather conditions; its sticks from the charcoal packing were used first thing next morning, followed by the whole of clone 50 and the green sticks of clone 80; the brown sticks of clone 80 and the whole of clone 163 were left for the following day (August 26th) and were completed by noon of that day, about 48 hours after budding had started. In that time 2113 buds had been cut and 1489 put on, making an average of about 150 buddings per man per full day.

V. Opening.

The fortnight following the completion of this budding provided ideal growing weather with frequent showers.

Opening was started on 12th September, the 19th day after budding had been started, and was completed next day. As will be seen from the table, a total percentage of 86 successes or an average of 10.7 buds per metre was obtained, but clone 50 gave over 95% successes and 14.5 buds per metre.

METHODS OF PACKING BUDWOOD.

Experiment performed on Effingham Estate.

	Clone No.	Fibre. No. of Buds cut.	Fibre. No. of Stumps Budded.	Fibre. Successes.	Fibre. Failures.	Fibre. Percentage Successful.	Fibre. Successes per Metre.	Banana. No. of Buds cut.	Banana. No. of Stumps budded.	Banana. Successes.	Banana. Failures.	Banana. Percentage Successful	Banana. Successes per Metre.	Charcoal. No. of Buds cut.	Charcoal. No. of Stumps Budded.	Charcoal. Successes.	Charcoal. Failures.	Charcoal. Percentage Successful.	Charcoal. Successes per Metre.	Total. No. of Buds cut.	Total. No. of Stumps Budded.	Total. Successes.	Total. Failures.	Total. Percentage Successful.	Total. Successes per Metre.
49	Brown	98	50	49	1	98	9·8	92	42	39	3	93	7·8	111	71	45	26	63	9·0	301	163	133	30	82	8·9
	Green	83	35	28	7	80	5·6	84	54	42	12	78	8·4	79	53	36	17	68	7·2	246	142	106	36	75	7·1
50	Brown	90	79	74	5	94	14·8	102	87	81	6	93	16·2	113	92	88	4	96	17·6	305	258	243	15	94	16·2
	Green	81	66	63	3	95	12·6	80	66	66	0	100	13·2	80	66	62	4	94	12·4	241	198	191	7	96	12·7
80	Brown	94	68	60	8	88	12·0	94	77	74	3	96	14·8	108	92	80	12	87	16·0	296	237	214	23	90	14·3
	Green	62	56	44	12	79	8·8	80	63	56	7	89	11·2	83	68	55	13	81	11·0	225	187	155	32	83	10·3
163	Brown	87	54	50	4	93	10·0	95	44	39	5	89	7·8	91	70	65	5	93	13·0	273	168	154	14	92	10·3
	Green	81	50	25	25	50	5·0	72	43	33	10	77	6·6	73	43	26	17	60	5·2	226	136	84	52	62	5·6
Totals	Brown	369	251	233	18	93	11·65	383	250	233	17	93	11·65	423	325	278	47	86	13·9	1175	826	744	82	90	12·4
	Green	307	207	160	47	77	8·0	316	226	197	29	87	9·85	315	230	179	51	78	8·95	938	663	536	127	81	8·9
	Together	676	458	393	65	86	9·8	699	476	430	46	90	10·9	738	555	457	98	82	11·4	2113	1489	1280	209	86	10·7

VI. Brown Wood.

Inspection of the results from brown wood shows remarkable consistency. There is only one low percentage figure, namely 63 for clone 49 packed in charcoal; but associated with this figure we get the highest recorded number of buds cut and a large number of stumps budded; consequently the number of successes per metre is found actually to be slightly higher than the average for the clone. On examining the figures for individual rows, which are not published, we find that one budder put on 12 buds, all of which succeeded, while the others all put on more buds but had many failures.

The next lowest percentage figure (87) again comes from charcoal packing; here the successes (16) are actually more numerous than those obtained from either of the other two packings of the same clone (80); the next lowest percentage comes from the fibre packing of the same clone (80), is only one point higher (88) and gives only 12 successes per metre.

Another feature of the brown wood group is the low number of successes per metre obtained from the banana packing of clone 163. This was the last bundle to be dealt with except for the brown wood of the same clone packed in fibre. It is obvious from the figures that the budders tried bud after bud but succeeded in putting on less than half of those cut. However the vitality of such buds as were put on appears not to have been seriously affected.

Considering the total for the brown wood of all the clones together, no significant difference appears between the fibre and banana packings; on the contrary the approximation is remarkably close. The charcoal packing on the other hand shows an appreciably lower percentage success but at the same time many more usable buds and therefore a considerably higher number of successes per metre.

The charcoal and sacking method then presumably tends to keep the bark of brown wood more pliable and tractable without affecting, or at any rate depreciating, the vitality of the buds.

VII. Green Wood.

Turning now to the green wood by itself, we note firstly that an equal number of buddings was obtained from each packing of clone 50, namely 66; the number of failures is too small to be significant.

In clone 49 we find small success per metre associated with high percentage success in the case of the fibre packing, but with low percentage success in the case of the charcoal packing. The trouble with the fibre packing stands out clearly in the individual row figures; there was no lack of buds available —83— and such as were put on show vitality (80% success); but the less experienced estate budders found it difficult to strip properly the less tractable green buds. A short lesson from a conductor on stripping with the teeth proved very effective as subsequent results show. In the mean time the fibre packing appears at some disadvantage.

The reason for a proportionately low percentage success combined with too few successes per metre in the case of the charcoal packing of this clone is not so easily traced. The failures are spread fairly evenly amongst the budders. Any attempt to explain the facts would be mere speculation.

Taking clone 80, the charcoal packing provided many tractable buds but no more successes per metre than the banana packing, being a repetition of the conclusion from the brown sticks, while the fibre packing is rather low all round with casualties fairly evenly distributed amongst the budders.

Clone 163 shows poor results for all packings, particularly for the fibre packing which at the same time provided the largest number of buds for cutting and also of buds put on. A study of the individual row figures here is illuminating; arranging them in order of superiority we find the five sticks disposed as follows:—

	Successes.	Failures.
	11	2
	6	1
	4	3
	2	8
	2	11
Total for five sticks	25	25

Taking the first three sticks by themselves, we find 21 successes out of 27 buddings which gives a percentage of nearly 78 and 7 successful buds per metre which, although still not high, compares very favourably with the figure obtained for the banana packing. The last and worst figure was obained by one of the conductors who has been getting good results consistently for the last

six months and whose work was in this experiment entirely satisfactory otherwise. The stick which gave 2 successes and 8 failures was used by a coolie whose work was also of a high standard otherwise. The personal factor may therefore be discounted and we are driven to the conclusion that two, if not three, of these sticks had been damaged. We have already pointed out that the coconut fibre did not in fact protect the sticks from rubbing against the sides of the box and are therefore inclined to attribute these figures to this cause. Unfortunately sticks found at the sides of the box were not marked at the time of opening so the case must pass as not proven.

The charcoal packing of this clone (163) gave, in addition to a low percentage success, few usable buds per metre, the only instance for this method of packing; the failures are again evenly distributed amongst the operators. The remarkable difference between the green wood and brown wood of this clone and packing should be noticed.

Summing up the results for the greenwood of all clones together, the charcoal packing is found to have much the same percentage success when compared with banana packing as it had before in the case of the brown wood; also it still has a few more usable buds than were found with the banana packing. The fibre packing has dropped in both respects. As we have seen it was handicapped both by a few remarkably poor sticks and also by the stripping difficulties of the estate coolies in the first bed budded.

Two further points of interest arise from this experiment, namely a comparison between brown budwood and green and also a comparison between the results obtained by practiced budding conductors and ordinary estate budding coolies.

VIII. Brown Budwood versus Green.

Summers in the Manual (2) referred to above speaks of the risks of using very young green wood as budwood; greenwood undoubtedly has a bad reputation and is more difficult to strip. Much, if not most, of the green wood used in this experiment was very thin and young. It was used turn and turn about with the brown and in equal quantities. It was given a slight advantage in the case of clone 80 when the green sticks were used overnight and the brown first thing next morning.

A glance at the table shows in every case more buds cut from the brown sticks than from the green; in every case except one, more stumps budded from the brown group than the green; in 9

cases out of 12 a higher percentage obtained. In spite of this the green wood has given successes in the proportion of 42 from green wood to 58 from brown wood with a very reasonable percentage and number of buds per metre. Green wood produced both the highest percentage per five sticks (100) and the lowest (50).

IX. Budders.

The work of the budders can be examined most easily by tabulating their successes. These figures refer to three clones only.

	Conductors.		Coolies.		
	I	II	1	2	3
Percentage success	95	81	90	87	85
Successes per Metre	13·3	12·2	11·6	8·8	9·7
No. of buds cut.	253	273	232	181	207

The top line shows that one of the conductors obtained the lowest percentage and the bottom one the reason for it; as the wood was valuable, he used every bud there was, while the estate coolies missed a few and left the more difficult ones such as are found at the top of green sticks.

This shows that more attention should be paid in the training of coolies to the stripping and selection of buds.

The conductors got about 50% more successes than the worst estate coolie, and 8 and 15% respectively more than the best.

It may be mentioned that the estate coolies put on four buds upside down; these all took and are reckoned as successes though subsequently cut out.

A patch not containing a bud was put on but did not take.

On a second examination 10 days later only 2 further casualties were found, one from clone 80 and one from clone 163.

X. Conclusions.

From a review of the results of this experiment as a whole it may at least be said that, for a journey such as this of approximately three days, all three methods of packing have proved

themselves suitable. The duration of the journey was such as frequently occurs in transport of budwood between Sumatra and Malaya or within Malaya itself. To enable us to differentiate definitely between the various methods of packing a longer journey is evidently necessary. We hope therefore to carry out when the opportunity offers a further experiment on lines similar except for the length of time occupied in the journey. If we were compelled in the meantime to recommend any one method in particular, we should not forget that the charcoal and sacking method appears to keep the bark in a more pliable and tractable condition.

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NOTE ON THE DECAY OF THE "SNAG" AFTER BUDDING.

By J. R. WEIR.

From the time the snag is formed by ringing or cutting off the stock some distance above the developing bud to the time it is cut off flush with the bud or is allowed to rot away as is the practice at the A.V.R.O.S. in Sumatra wood destroying and other fungi are usually present in its gradually drying tissues.

In order to answer inquiries received concerning the significance of the presence of these fungi in relation to the present and future well being of the budded tree the following brief resume of some observations are here presented.

The rapidity with which the stock above the bud becomes subject to fungous action after cutting off the top depends largely upon the rapidity with which its tissues are invaded by the ubiquitous Diplodia. Ordinarily there is considerable enzymic antagonism between two different species of fungi working in the same substratum (1). If Diplodia is one of the contending organisms the advance of a true wood-destroying species is apparently not retarded. If the stocks are transplanted to infertile soil with poorly developed rootlets or if the roots have been drastically pruned, the wood is rapidly invaded by that fungus. This would be without significance if it were not for the fact that under such conditions of poor nourishment the stock is unable to develop rapidly after the utilization of stored materials and the fungus may attack the tissues below the bud (E). The impetus of the advance may be increased at the time of ringing and scraping if that method is employed. If the top horizontal cut in budding is made too deep into the wood of the stock preventing for a time the rapid downward flow of an adequate amount of food materials, or if too much of the tissues of the stock are left exposed around the bud patch Diplodia under conditions of poor nourishment and slow callus development may cause the death of the entire stock. The fungus is also in the top soil and will attack the larger wounds made in pruning the laterals.

Budded stumps are not so liable to attack by Diplodia if the roots are dipped in Bordeaux mixture or painted with Bordeaux paste. In view of the results obtained by several investigators working on soil and seed disinfection the use of soluble salts of

copper, mercury, lead, zinc, etc., copper especially holds much promise as a means of combating the early infection of stumps and young trees by various fungi. This subject is being investigated by the Pathological Division.

Diplodia on the dead stock above the developing bud is usually followed by a number of saprophytic fungi such as Nummularia, Diaporthe and Eutype. These do not break down the wood in the usual sense but produce black lines and may be disregarded (A). They are usually followed by the true wood destroying species. Of the latter the species so far collected are *Schizophyllum alneum*, *Polystictus occidentalis*, *P. arenicolor*, *Daedalea repanda*, *Polyporus ostreiformis* and *Trametes corrugata*. These have received attention for the reason that the decay they produce sometimes extends well below and within the living enveloping tissues of the stock (A-H). The fungi however are not parasitic.

If the snag is cut off flush with the top of the bud the cut sloping downward away from the bud and at the proper time say when the bud has grown 4—8′ and shows considerable brown bark the amount of decayed wood remaining on the stock may be very little or may be entirely absent (C). When such a stock is sectioned lengthwise there may be scarcely a trace of brown wood. In many cases however especially if the snag is cut square across or cut too high, the decay may advance so far, below the point where the cut is usually made that an appreciable amount of decayed wood may be sealed in by the callus tissues (A, B, D, E). The decayed wood next to the bud side of the stock may before the callus is complete cause the young tree to be overthrown by the wind. Also the shoot may be broken off by the wind if the cut exposes the decay so close to the bud that the callus does not form rapidly at that point.

The hyphae present in the zone of enclosed dead wood are usually characteristic of the wood destroying fungi named above. Shortly after the snag is removed if there is decayed wood remaining the hyphae are found to be viable. Repeated attempts to culture the fungi from the wood after the callus has been closed for some time have not been successful. It would appear that following the sealing up of the wood the hyphae already inhibited by the living surrounding wood are gradually asphixiated. Similar results have been obtained by the writer during the course of an investigation on the influence of thinning on the growth of heart wood fungi in certain forest trees (2).

The remaining consideration is the possible influence of the presence of a zone of decayed wood within the callus on the upward

advance of Termites in the heart wood of young trees. If the tap root is attacked by root disease Termites if present may be expected to seize the opportunity to attack the tree (E). As they work upward in the heart wood they will come eventually to the decayed or brown wood zone so that they will advance more rapidly or will hollow out the wood to a greater extent in a radial direction. Termites however as a rule follow fungus attack or such injuries or abnormalities of the roots as will enable them to enter. With increasing age of the tree the influence of the zone of dead wood becomes less important and may be disregarded both from the standpoint of its possible influence on mechanical strength and in its relation to disease and insect attack (F).

If the snag is allowed to rot away—a process usually assisted by Termites—a crater is frequently formed in the top of the stock (D, G, H). Although this cavity may not be so rapidly occluded as the smooth surface of the stock when cut off with a knife or saw it is as a rule completely filled with firm living wood by the inrolling callus. The decayed wood is in many cases completely eaten out by Termites consequently there is no dead wood zone enclosed by the callus tissues.

Among the substances used to disinfect and to protect the exposed wood after sawing off the snag are coal tar, coal tar products and melted budding wax. The wax is said to prevent Termite attack. The subject is being investigated. In the A.V.R.O.S. method no protective or disinfective agent is employed.

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DESCRIPTION OF PLATES.

A. Effects of too late pruning. The snag is only partially decayed and is still of firm texture. The callus grows up around the snag and when the wood finally decays a deep crater is formed. Note the weak connection of the budding and stock. See also E.

B. Effects of decay of the snag in multiplication nursery. In both the stock and original budding the decay has affected the tissues of the callus thereby reducing the mechanical strength of the union.

C. Showing the rapid advance of the callus over the sloping surface of pruned stock. A small amount of decayed wood is inclosed.

D. The disintegration of an unpruned snag by Termites and decay causing the formation of a cavity which may later be filled by the process as shown in F.

E. Action of Diplodia and wood destroying fungi on a snag not properly pruned or treated. The callus has been unable to develop. The pruned end of the tap root is attacked by fungi followed by Termites. See also A.

F. Healing of a naturally pruned snag. The growing margins of the callus become incurved eventually filling the cavity.

G. Secondary formation of crater due to dying back of budding after removal in multiplication work and its subsequent regeneration.

H. Showing the action of Termites on snag.

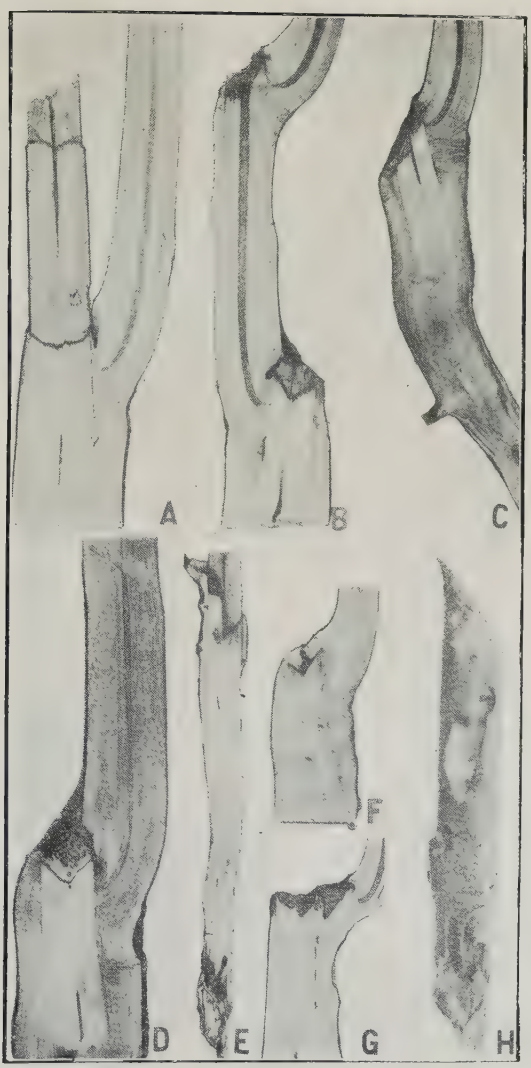

PLATE IV. Re. Note on the decay of the snag after budding.

NOTES ON THE CONCENTRATION OF LATEX.

By R. G. FULLERTON.

In the past few years the increase in the direct application of latex to the manufacture of rubber articles and in its application in industries which formerly made use of rubber solutions or adhesives of various compositions, led to an increase in the shipments of liquid latex, and demonstrated the necessity for research in this field with the object of finding the most effective method for its preservation and of reducing the content of water so as to lower the cost of transport. It is perhaps not generally realised that when rubber in latex form, particularly in the form of concentrated latex, reaches the manufacturer, it is seldom subjected to preliminary processes of coagulation, sheeting, and crepeing as practised on the plantations where it is harvested, but may be used in almost all of the processes through which ordinary plantation rubber passes before it is converted into the vulcanised or unvulcanised articles of commerce.

Before passing to a consideration of methods for the shipment of latex in concentrated form, it may be mentioned that in recent years a small fraction of the total output of rubber from the producing countries has been preserved for shipment in latex form by the addition of an aqueous solution of ammonia, which is one of the best preservatives so far used in this connection, while formalin has also been found to give very successful results. These are, however, methods for the preservation of the latex in liquid form without at the same time leading to an increase in its rubber content.

The results of modern investigations have shown that in Hevea latex the rubber is dispersed or scattered throughout the serum liquid in the form of very small particles varying in size roughly from $\frac{1}{2000}$ millimetres to $\frac{1}{500}$ millimetres. The particles also vary in shape as will be seen on reference to Fig. 1 which is a photograph of dilute, fresh latex, the magnification employed being 1000. Fresh latex is kept stable and prevented from coagulation by substances contained in the serum, but as is well known it will not keep in good condition for very long unless other substances are added to it to prevent its coagulation. For ordinary purposes substances such as sodium sulphite and formalin are suitable, but if it is desired to produce a latex of very high dry rubber content, a substance such as egg albumen, glue, gelatin, or soap has to be employed. Because of their nature such substances are known as protective colloids.

At the present time two different processes are in operation in Malaya for the preparation of latex in concentrated form. According to one method, the latex, after stabilisation by the addition of a small quantity of a solution of ammonia, is fed by gravity into a battery of Alfa-Laval Centrifuges or Separators such as are used for the separation of cows' milk into cream and "skimmed" milk. The essential part of the centrifuge is the bowl, which is capable of revolution at a high speed about a vertical axis, the speed usually employed for latex separation being about 8,500 revolutions per minute. The bowl contains a series of conical steel flanges, superimposed and set in a hollow vertical shaft which passes through the centre of the bowl, and the inflowing latex meeting these swiftly rotating discs is caused to separate into a cream containing most of the rubber and a "skim" containing most of the serum and a very little rubber. There being a slight difference in the specific gravity of the rubber particles and of the serum liquid, when the contents of the bowl are rotated at high speed, a greater centrifugal force is applied to the serum liquid than to the rubber particles, with the result that the bulk of the rubber passes towards the central axis while the serum passes towards the outside walls of the bowl. A very simple distributing device then carries the cream and the "skim" into separate exit tubes. By the addition of a suitable quantity of ammonia a cream latex may be obtained having a dry rubber content of 57 per cent., but there is reason to believe that by the addition of a suitable protective colloid such as, for example, as aqueous solution of a very pure soap, the rubber content may be brought as high as 70 per cent. The concentrated latex thus obtained is shipped in sealed drums and is a reversible product—that is, by dilution with water the concentrate can be re-converted to a stable latex, the dry rubber content of which may be varied by varying the quantity of water used for dilution.

The other process to which reference is made above is known as the "Revertex" process, this name being given to it on account of the fact that this product is also a reversible concentrate. According to this method, a special protective colloid is added to the latex on its arrival at the factory in order to increase its stability. The latex is then subjected to evaporation in large horizontally rotating steel drums which are heated by oil fuel burners. Inside the drum is a smaller freely moving cylinder placed with its axis parallel to that of the large drum, which during its revolution causes this cylinder to rotate with it, the result being that a thin film of latex is continuously exposed to the hot atmosphere inside the drum and thorough mixing of the bulk of the latex is automatically effected. The object of the addition of the protective colloid

Fig. 1. Dilute Fresh Latex.
(X 1000)

Fig 2. Dilute Latex prepared from
a Concentrate containing
68% "Dry Rubber."
(X 1000)

PLATE V.

is to prevent the coagulation of the latex which would otherwise take place at the temperature of evaporation employed. The extent of the evaporation is controlled so as to produce a concentrate containing about 70 per cent. of rubber, and it is packed for export in small Venesta Cases coated on the inside with paraffin wax.

Investigations carried out by the Institute showed that by very simple methods of evaporation on a small scale, stable concentrates having an average rubber content of about 70 per cent. could be prepared by adding suitable quantities of an alkali and of a protective colloid to the latex before evaporation. Some of the most successful results were obtained by the addition to the latex of 0.5 per cent. by weight of potassium hydroxide and 1.0 per cent. of soaps such as potassium stearate, sodium oleate, or sodium palmitate. These concentrates have been found to be stable and completely reversible after a period of two and a half months' storage in sealed containers. Figure No. 2 is a photograph (magnification 1000) of a dilute latex obtained from one of these concentrates which had been stored in a sealed container for a period of ten weeks. This concentrate was prepared by the evaporation of fresh latex of 40 per cent. dry rubber content in the presence of 0.5 per cent. of potassium hydroxide and 1.0 per cent. of potassium stearate, the dry rubber content of the finally prepared concentrate being 68 per cent. The photograph shows that the particles are distributed throughout the liquid and that they remain uncoalesced. The concentrates therefore remained in good condition during a considerable period of time under storage, and stable latices of various dry rubber contents were prepared from them by suitable dilution with water. Very good results were also obtained by the use of other protective colloids, and experiments are still in progress in this direction.

Certain scientific investigators claim that vulcanised rubber manufactured from concentrated latex prepared by these processes is superior as regards physical properties and ageing qualities to vulcanised articles made from plantation smoked sheet and crepe. Again they state that a considerable economy in motive power consumption is effected in vulcanising factories during the mixing of the sulphur and other ingredients on the machine rolls, since all that is necessary is to add the concentrated latex and the admixed ingredients directly to the "mixing machine", the heated rolls of which soon effect the evaporation of the latex. There are, however, certain difficulties to be overcome in this direction and the whole subject requires further investigation before more definite recommendations can be made as to the shipment of large quantities of rubber in this form.

A BLIGHT OF YOUNG BUDDINGS.

By J. R. WEIR.

Inquiry as to the diseases that may be expected on young buddings before they are fully established has always elicited the reply that none may be expected that are not already known to attack seedlings of the same age and vigour. Observations so far in Malaya and Sumatra indicate that this is the correct point of view.

A blight of young buddings which may prove to be important has recently been studied. The budding is attacked at its extremity and unless prevented the blight will extend downward and destroy the entire shoot. The disease is first noticed by a browning and blackening of the tender tip. Ordinarily the blight is confined to the more succulent parts of the shoot and stops when the older tissues of the bud patch and stock are reached. Damp weather favours the blight especially if the buddings in the field are closely surrounded by a cover crop. In nurseries where there is a clear sweep of air beneath the budded plants the blight is not so likely to occur.

The blight has been observed at three different stations in Malaya and twice in Sumatra. In one case a small white grub had entered at the base of the dead shoot. The grub appeared to be secondary. Seedlings are also attacked by the blight.

Examinations of the affected sheets have not yet been sufficiently conclusive to enable the causal organism to be definitely determined. The investigations so far disclose among two other fungi the presence of a Phytophthora which may be the responsible agent. Mites are sometimes present. Planters are requested to send in blights affecting young bud shoots for experimental purposes.

When bud shoots are observed to blacken and shrivel at the tips the diseased parts should be pinched off well below the affected tissues and burned. Cover crops should not be allowed to grow closely around the budded stumps. This promotes moisture and for the same reason damp situations should be avoided unless adequately drained. Most blights of the kind may be successfully controlled by spraying with standard Bordeaux mixture or, if good stone lime is not available, sodium carbonate (Sal soda) may be used (Burgundy Mixture).

INSTRUCTIONS FOR SENDING PATHOLOGICAL MATERIAL AND INSECT PESTS TO THE RUBBER RESEARCH INSTITUTE.

By J. R. WEIR.

The annual loss in production of latex in British Malaya from disease and to a less extent from insect pests is probably well over 6 per cent. of the total. Judging from figures obtained for some estates the losses have approximated 4.2 per cent. in 8 months. When it is realised that on many estates the average is down to 50 to 60 trees per acre the importance of disease control is apparent. On many of the older estates root disease has become so prevalent that individual treatment of trees is not practicable. For such areas the only plan of management is to tap the trees as long as it can be done with profit at the same time practising such methods as will arrest the spread of disease from centers of infection and replant. The only object in calling attention to this situation which undoubtedly will become worse on some of the early planted areas is to show the necessity of a careful investigation of the organisms causing disease and the conditions under which they operate. It is not our purpose to express our views as to the probable status of health the old areas might have shown under a more careful consideration of disease and disease conditions. It is safe to assume however that if more attention had been given to the subject the older areas would have been in a better condition to-day.

In order to serve the best interests of the planting community the Pathological Division of the Institute while carrying out a programme of investigation into the nature and cause of disease in rubber for the purpose of devising means of control will answer letters of inquiry regarding pests and diseases and offers the following suggestions, for collecting and sending specimens.

Letters transmitting material for examination should give all the particulars regarding the trouble. The extent of the injury and effects on the tree should be given. The material will be studied and instructions given for the treatment of the disease. As often as possible and especially in serious cases an officer of the Division will be sent to study conditions on the estate.

Material should be carefully selected. What may appear as early and late stages of the disease should always be included.

Root decays should include incipient stages as well as the final or advanced stages. Collections should be ample. It is frequently difficult to make a correct diagnosis from material without a full knowledge of field conditions. This difficulty may be made easier if material is in sufficient quantity. Fructifications of all fungi which appear to be associated with the disease should always be included. Specimens should be promptly packed and mailed as soon as possible. They may be packed in any kind of a box or wrapped in thick strong paper. Never wet specimens to prevent them from drying or treat them in any way. Don't use cotton for wrapping. It interferes with the study of the specimens.

Infected leaves and small seedlings are best sent rolled up between the pages of old newspapers. This keeps the leaves flat if they should dry up enroute.

Stumps may be tied into a bundle and wrapped in strong paper.

The name of the sender and estate should be written on the outside of the package.

In sending insects it is better to pack in tight tin or wooden boxes, enclosing sufficient food to last them for a few days.

Prepay all material sent.

Address packages and letters to the Director, Rubber Research Institute of Malaya.

EXPERIMENTS ON THE POLLINATION OF HEVEA BRASILIENSIS. 2.

By

L. E. Morris.

Following on the previous paper (2) describing the pollinations carried out in May and June 1928 it is now possible to give the results of further experiments made in August and September on the young budded trees on Pilmoor Estate, Selangor, which were planted out as stumps at the end of 1924.

The results are shown in full in the Table, from which it will be seen that seven clones were crossed in nineteen combinations. From 1248 cross pollinations 91 fruits were obtained, that is 7.3 per cent were successful. The success varied greatly with the different crosses: four combinations were unsuccessful while others, for example A44 × B16 and A44 × D61, gave 20 per cent success and over. (In some crosses, owing to the scarcity of flowers on the young trees, very few flowers were used, and the percentage success might have been different with larger numbers.) These differences resemble those that have been described already by Heusser (1) for his work in Sumatra in 1920.

It is to be noted further that the success of crossing two trees (or clones) may depend largely on which is used as the mother. For example, although the cross pollinations between A44 and D61 were nearly equally successful in both directions, yet with A44 and B16 20 per cent of success was obtained with the first as mother while the reciprocal cross gave only 4 per cent. Again when A8 and B58 were crossed 3 per cent of the pollinations succeeded in the one direction and 13 per cent in the other. Similar results have been found in the Dutch East Indies: H. Rr. (3) in his review of the previous paper (2) states that his best cross in 1928 at Buitenzorg gave 52.9 per cent of success and yet in the reverse direction the success was merely 5 per cent.

The number of fruit obtained however does not represent the real success, as this depends also on the number of seeds that germinate.

The eleven fruits picked from clone A8 all looked normal, but the seeds in seven of them though full sized were light in weight, and contained merely the remains of the nucellus with no embryo or with both embryo and endosperm in various stages of arrested development. This behaviour was not confined to the fruit from artificial pollinations, for ordinary fruit picked from the same trees

at the same time also contained about 27 per cent of light seeds. In the preceding season as well a number of light seeds had been noticed.

From each of the crosses B58 x A44, B58 x D61, D61 x A44, and D61 x B16, (the mother clone is always mentioned first) two fruits of normal appearance enclosed light weight seeds. In addition one fruit from the cross D61 x B16 and two from D61 x A44 were imperfectly developed and small, although they remained on the trees for the usual time and their outer coats (exocarp) had started splitting when they were picked.

It may be interesting to compare the results of May and June with those of August and September. In the first season 134 flowers of A44 crossed with B58 gave 2 fruits, that is 0.8 per cent of success, and 6 seedlings, and in the second 43 flowers gave 3 fruits, that is 7 per cent, and 6 seedlings. The reciprocal cross B58 × A44 from 257 flowers gave 1 fruit, or 0.4 per cent of success, and 2 seedlings from the earlier pollinations, and 2 fruits from 42 flowers, i.e. 5 per cent, but no viable seeds from the later ones. (The numbers previously quoted (2) for the first season are incorrect owing to the subsequent discovery that one tree labelled A44 was a rogue and really A8.)

All the self-pollinations failed. Of 138 flowers of B58 pollinated with B58 pollen in September and of 255 in May and June not one set fruit.

The complete results for 1928 can be summarised thus:—2290 flowers of 8 clones were pollinated. 1685 crosses gave 94 fruits, i.e. 5.5 per cent of success, and 213 seeds germinated. 605 self-pollinations all failed.

The seedlings obtained have been planted out in the Rubber Research Institute Experiment Station at Sungei Buloh together with ordinary seed from the same clones and commercial "selected" seed as a basis of comparison

As indicated before, evidence was collected as to the conditions affecting the success of pollination and rather striking results were obtained. It is considered desirable however to gain additional information from this year's work before giving the results in detail. Briefly success was found to increase from morning to afternoon, while the age of the flower and rain also appeared to have a considerable influence.

This has a definite bearing on the methods used for pollination and justifies the continuance of bagging (which was used all last year) for afternoon work especially, whereas the quicker plugging method of Heusser is practically restricted to the morning, as it depends on pollination before the opening of the flower. Each method has points in its favour, and during this year the two are being used together.

CROSS POLLINATIONS OF HEVEA IN AUGUST AND SEPTEMBER 1928.

Parent Clones		Number of Female Flowers.	Number of Inflores-cences.	Number of Fruit Obtained.	Per cent of Success.	Number of Seeds Picked.	Number of Seeds Germinated
Female.	Male.						
A8	A44	261	37	9	3.4	27	10
	B58	59	7	2	3.4	6	2
A44	A8	39	9	0	..	..	..
	B58	43	7	3	7.0	9	6
	B84	12	2	0		..	..
	D61	57	10	12	21.0	36	34
	B16	50	11	10	20.0	30	27
	B95	22	8	0	..	..	..
B58	A8	54	6	7	12.9	21	19
	A44	42	8	2	4.7	6	0
	D61	71	7	5	7.0	15	10
	B16	115	12	4	3.5	12	11
	B95	61	7	0	..	..	..
B84	A44	10	3	3	30.0	10	10
D61	A44	104	14	19	18.3	57	47
	B16	29	4	7	24.1	21	10
B16	A44	100	13	4	4.0	12	8
	B58	53	10	1	1.9	3	2
B95	A44	66	11	3	4.5	9	9
		1248	186	91	7.3	274	205

Self Pollinations.

A8		31	3	0			
A44		20	4	0			
B58		138	20	0			
D61		6	1	0			
		195	28	0			

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OBSERVATIONS ON BARK THICKNESS AND RENEWAL IN MALAYAN BUDDINGS.

By

F. Billington.

Introduction.

One of the commonest objections advanced against budding is that budded trees may not be able to provide bark adequate for tapping nor to renew bark tapped. The foundation for this fear is not easy to discover. The few references to bark character that can be found in the literature of budding are scarcely likely to prejudice the minds of readers against the practice.

Previous References.

The only contributor who has much to say on the subject is Heusser, who, in his first paper on the experimental tapping of Hevea buddings (3, p. 66), says "As far as I can judge from observations made so far, bark renewal leaves nothing to be desired. It is however not impossible that in the course of time it will turn out to be less good than in the case of strongly growing seedlings, and that budded trees will have to be allowed a longer period for bark renewal than trees grown from seed". In a second paper (4, p. 692) he says "Generally speaking this (bark renewal) seems to be a little less vigorous than that of strongly growing seedlings which are tapped for the first time. This is not so with clone AVROS 50, however; the bark renewal of this clone is as good as that of seedlings. The oldest renewed bark, now two years old, has an adequate thickness and the panels are beautifully arched and without edges or holes, as is sometimes seen when bark renewal is bad". Of the other AVROS clones under discussion, he describes clones 80, 52 and 36 as giving no cause for anxiety, and clone 33, standing on a clay soil, as giving the impression that it renews its bark more slowly. In a later paper (5) he refers to bark thickness in four clones: clone AVROS 80, referred to in the second paper as giving no cause for anxiety, is now good, having renewed about 6 mm. in 16 months. Of the other three, which are not referred to previously, clone AVROS 51 had thick bark and good renewal; in clones AVROS 71 and 152 the renewed bark when 16 months old was 6—7 mm. thick while the normal thickness of primary bark was 8 mm. .

Heusser speaks only of the "possibility" of poor renewal in the future, and his later work proves that this possibility was realised in only one clone which gave the impression of renewing slowly. Further he implies that bark thickness and renewal are clone characters, not general characteristics of buddings.

Another reference to the subject comes from Java, for Gunst (1, p. 888) states that after 2½ years the renewed bark of the Bodjong Datar buddings was slightly better than that of seedlings of the same age.

Special Features of the Bark of Buddings.

Normally the bark of seedlings and buddings differs considerably in the amount of cork present. Cork consists only of dead cells and cannot therefore directly affect the productivity of a tree but its presence or absence does affect to some extent the tapping of the tree. Where there is plenty of cork, as in most seedlings, the tapper has room to rest the whole cutting edge of his knife upon the bark; whereas if but little cork is developed, as is usual with buddings, he can obtain support for only a portion of the cutting edge. Where much cork is present, a lip will be left on the outside of the cut which will tend to prevent latex spilling over the edge.

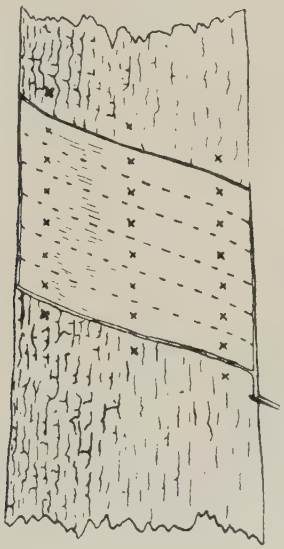
Although it is not uncommon for seedlings to have little cork, with buddings it is the rule, and it is owing to this scarcity of cork that the tapping of buddings requires a little extra skill.

Experiment on Pilmoor Estate.

With a view to obtaining information on bark thickness and the amount and rate of renewal in budded trees, measurements were made on some of those in tapping on Pilmoor Estate. These were budded in the first half of 1924 and transplanted as stumps at the end of 1924. They are mentioned on page 42 of the Annual Report 1928. Tapping was alternate daily in alternate months and the cut was spiral over half the girth. Tapping started in January 1928.

After a preliminary trial, complete records of bark thickness were taken on 23/28 July 1928 and again on 14/18 January 1929. On both occasions sets of 3 readings were taken from each tree, one set from each strip left after each month's tapping, one set in the virgin bark half an inch above the opening cut and a similar set half an inch below the most recent cut. As there were four monthly strips on the first occasion and six on the second, six and eight sets of readings respectively were taken from each

tree. The three readings of a set were taken, one at about one inch from each end of the strip and one in the middle. These readings were close to each of the three monthly tar marks. Vertically the readings were taken near the lower edges of the tar marks; as tapping started each time about the 12th day of the month and went on for one calendar month, the lower edge of a tar mark came almost at the middle of each tapping period. The crosses on the text figure below indicate the spots at which readings were taken.



The instrument used for these measurements was a Chesterman's Engineer's Depth gauge with a sharpened tongue: readings to one tenth of a millimetre were easily visible. This is the most suitable instrument yet met with for bark measurements of buddings and young seedlings. All instruments of this kind must penetrate the cambium and pass right to the wood, thus including in their register tissues that should, normally, not be touched by the tapper. This particular instrument has the further advantage that it leaves only a very small wound.

Fifty eight trees from four clones were tapped regularly throughout the period and from all these trees measurements were obtained as described above. The first records were taken while the trees were actually in tapping; it was noticeable that when readings fell as low as 0·5/0·6 mm. the bark looked greenish and tender, as though tapping had been as close to the cambium as was practicable without damaging it: a tapper is therefore allowing himself a safe margin if he never goes below 0·8 mm. from the wood.

TABLE OF BARK THICKNESS IN MM.

Clone.	Date of Recording.	Above Panel.	Tapped 1. Feb.	Tapped 1. Apr.	Tapped 1. June.	Tapped 20. July. 1. Aug.	Tapped 1. Oct.	Tapped 1. Dec.	Below Panel.
A 44	July 1928	5·8	4·4	3·9	3·1	1·2			5·5
	Jan. 1929	6·9	5·5	5·2	4·7	4·3	4·1	3·5	6·5
B 50	July 1928	5·1	4·2	3·7	2·8	1·1			4·7
	Jan. 1929	5·8	5·0	4·6	4·2	4·1	3·9	3·2	5·8
B 58	July 1928	5·7	4·5	4·1	3·2	1·0			5·5
	Jan. 1929	6·1	5·0	4·7	4·6	4·4	4·2	3·2	6·2
B 84	July 1928	7·0	5·2	4·7	3·8	1·3			6·7
	Jan. 1929	7·7	6·3	5·9	5·5	5·1	5·2	4·0	7·5
Average of Above	July 1928	6·0	4·6	4·1	3·2	1·2			5·6
	Jan. 1929	6·7	5·5	5·1	4·8	4·5	4·3	3·5	6·5
	Increase.	0·7	0·9	1·0	1·6	3·3	...	...	0·9
	Percentage Renewal.	...	77 82	69 77	54 71	67	65	52	...

Results.

The table opposite shows the average thickness at the two dates of recording for each strip of each clone and also of all the trees together. It will be noticed that individual clones maintained much the same position relative to the general average of bark thickness at both dates of measurement. Clone B 84 is in each case well above the average; clone A 44 is close to it; clone B 50 is consistently the worst.

Figures 1 and 2 have been compiled from the table. They represent the position at each of the dates of recording—the first date on the left page, the second date on the right. The figures for the best clone (B 84), the average, and the worst clone (B 50) are represented graphically in the right column: the black line shows the thickness of the worst clone, the shaded line that of the average, the white line that of the best clone. In the left column is given a sketch of a radial section of a typical panel to show the renewed bark and to indicate how the figures were obtained.

If Figures 1 and 2 be compared strip for strip, the amount can be found by which each strip has increased in thickness between the two dates of recording, as shown in Figure 3. The two strips tapped last (Oct. 1 and Dec. 1) had had only a portion of the full period for renewal: in both of these renewal has been reckoned as starting at 0·8 mm. from the wood, which allows the tapper his margin of cambium and a few cells outside it.

Figure 3 gives the impression that renewal was rapid immediately after tapping but slowed down considerably after the first few months. To verify this the amount of measured increase between 23/28 July 1928, or the date of tapping, if later, and 14/18 January 1929 was worked out for each strip on a time unit basis; the unit chosen was one week. Figure 4 shows graphically this average weekly increase for each strip. It demonstrates quite clearly that renewal was very rapid at first but slowed down later until, some six months after tapping, its apparent progress was very little faster than the normal progress of virgin bark. At this stage the renewed bark had become as hard to penetrate as virgin bark.

Percentage Renewal.

The figures for percentage renewal, as given in the table, appear very high. In this connection the following points should be borne in mind. Firstly, as has been pointed out above, the rate of renewal, rapid at first, slowed down as soon as the delicate cambium cells were well protected. Secondly the percen-

tage has been reckoned on the figures as they stand, although the first 10 to 15 per cent. is made up of cambium cells and "tapper's margin" which should not have been tapped. Thirdly the trees were still very young and active. Fourthly these figures represent the result of purely quantitative investigation and give no information on the quality of the bark: the newly formed tissues are as yet not necessarily fully organised and able to yield a normal quantity of latex.

Variability.

In all strips the variation of the three readings of the various sets is very striking and erratic. Readings along one strip vary from each other as a rule by between 0·4 and 0·7 mm. Differences of this order would scarcely call for comment but differences as great as 1·5 mm. and even 2·0 mm. between adjacent readings of one strip occur sufficiently often to require consideration, although they tend to become smoothed out in a table or diagram based on averages.

Differences in hardness of bark, flakes of cork, unevenness of pressure in inserting the instrument, vagaries of the tapper and so on would all cause variations, but hardly to the extent noticeable. Frequently no unevenness is apparent to the recorder. To examine these extreme figures more closely, during the second period of recording readings were taken from some trees at closer intervals along the strips, in one case as close as half an inch apart. The results found from tree 114 (clone A 44) illustrate clearly the kind of variation sometimes encountered. Seven readings were taken from each strip, the readings being about one inch apart; the results obtained have been plotted in the order in which they occurred and are given graphically in Figure 5. It will be noticed that unevenness is not confined to renewed bark but is equally striking in virgin bark.

In his microscopic examination of virgin bark, Haigh (2) took three samples from each tree, all at the same height. He found variation in all ways to be sufficiently great to eliminate almost entirely the personal error. He mentions three trees in each of which the three plugs, taken at the same height, were very variable. The tree showing the greatest divergence gave readings of 16, 15 and 6 mm., which are in the ratio of 2·7 : 2·5 : 1·0; he gives no other instance of a ratio higher than 2 : 1. In the case under review no divergence reached a ratio as high as 2 : 1. From his experience Haigh considers that the precaution of taking 3 samples per tree has been fully justified.

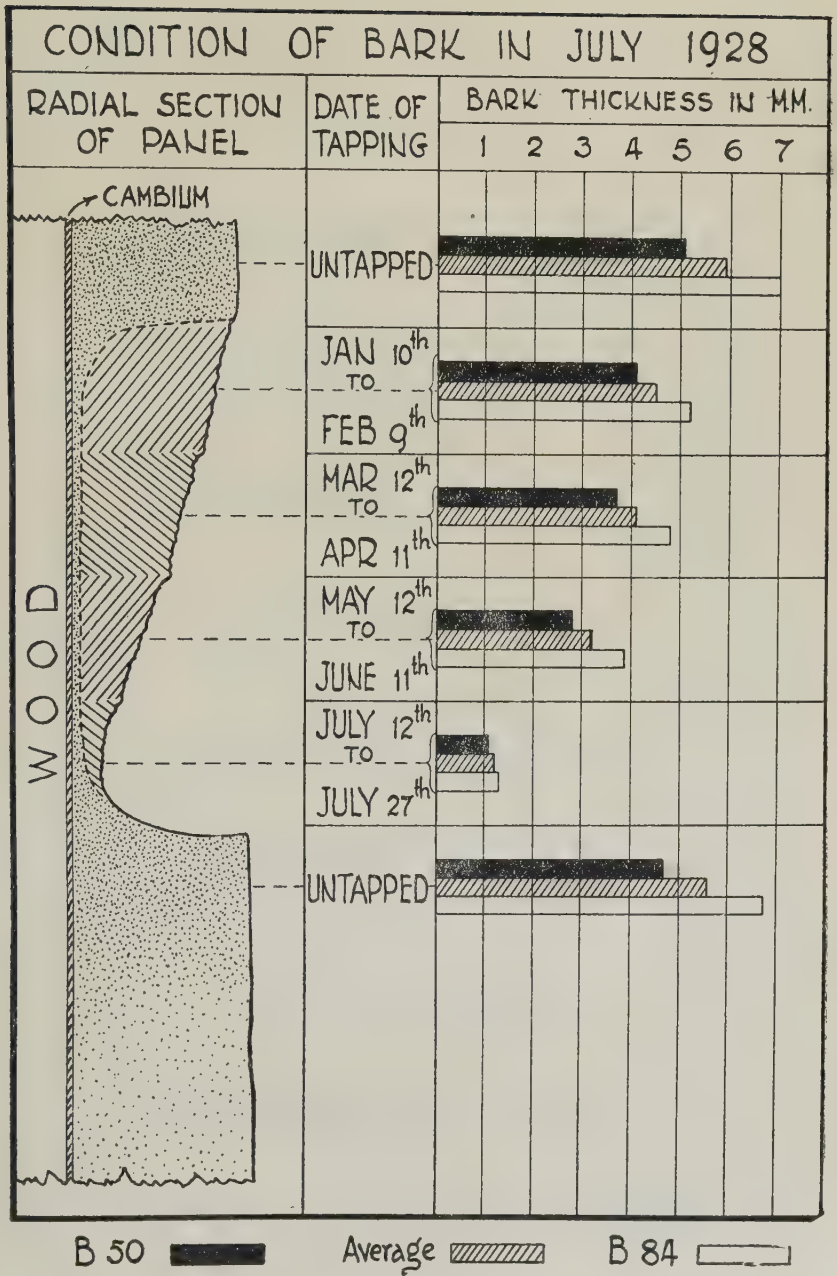

CONDITION OF BARK IN JULY 1928
RADIAL SECTION OF PANEL
DATE OF TAPPING
BARK THICKNESS IN MM.
1 2 3 4 5 6 7
CAMBIUM
WOOD
UNTAPPED
JAN 10th TO FEB 9th
MAR 12th TO APR 11th
MAY 12th TO JUNE 11th
JULY 12th TO JULY 27th
UNTAPPED
B 50
Average
B 84

FIGURE 1.

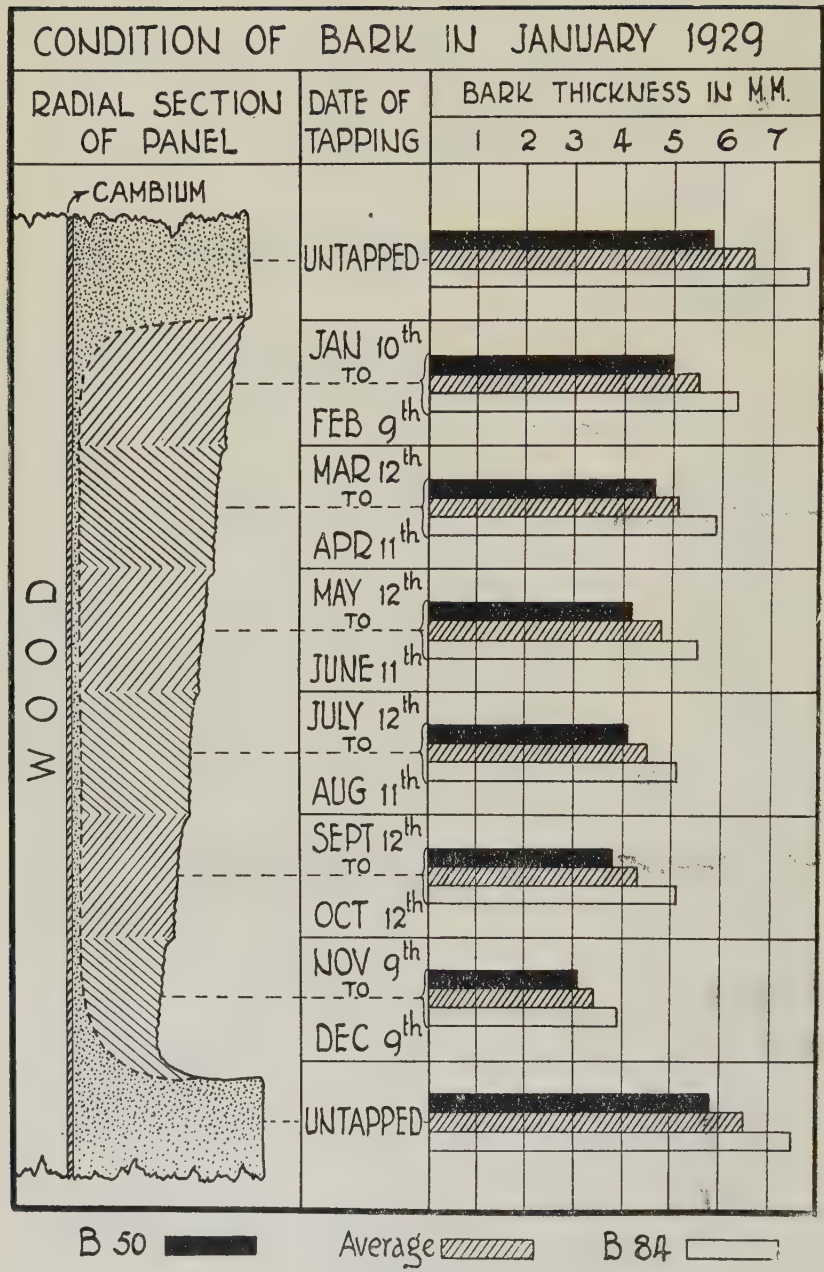

CONDITION OF BARK IN JANUARY 1929
RADIAL SECTION OF PANEL
DATE OF TAPPING
BARK THICKNESS IN M.M.
1 2 3 4 5 6 7
CAMBIUM
WOOD
UNTAPPED
JAN 10th TO FEB 9th
MAR 12th TO APR 11th
MAY 12th TO JUNE 11th
JULY 12th TO AUG 11th
SEPT 12th TO OCT 12th
NOV 9th TO DEC 9th
UNTAPPED
B 50
Average
B 84

FIGURE 2.

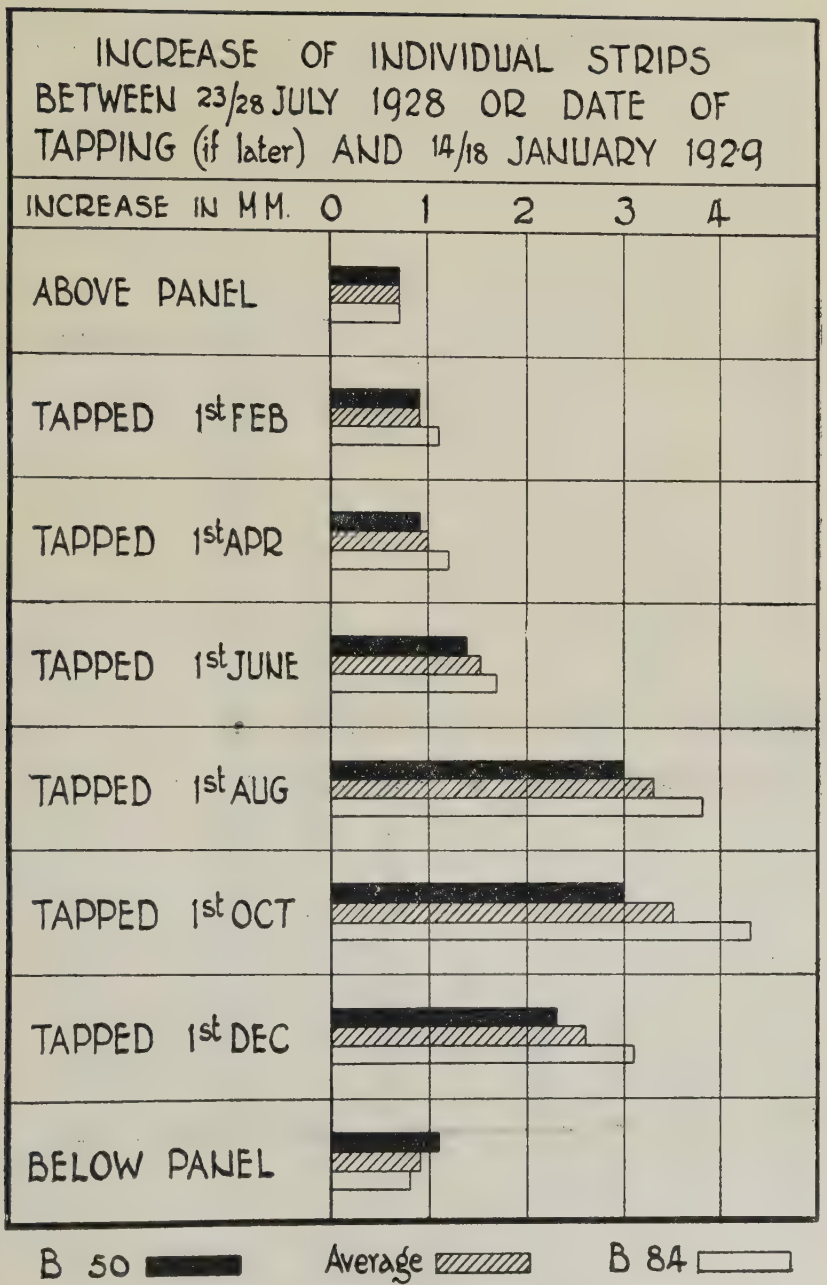

INCREASE OF INDIVIDUAL STRIPS BETWEEN 23/28 JULY 1928 OR DATE OF TAPPING (if later) AND 14/18 JANUARY 1929
INCREASE IN MM.
0
1
2
3
4
ABOVE PANEL
TAPPED 1st FEB
TAPPED 1st APR
TAPPED 1st JUNE
TAPPED 1st AUG
TAPPED 1st OCT
TAPPED 1st DEC
BELOW PANEL
B 50
Average
B 84

FIGURE 3.

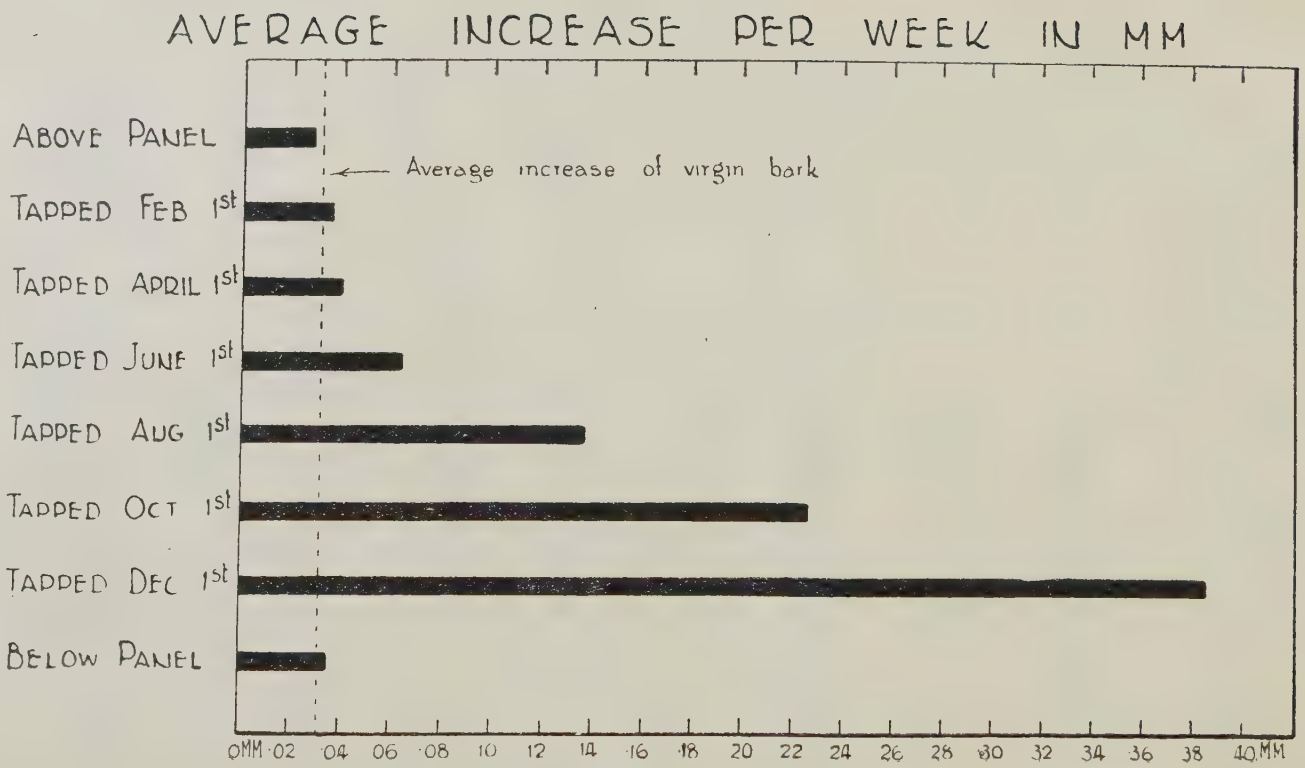

AVERAGE INCREASE PER WEEK IN MM
ABOVE PANEL
Average increase of virgin bark
TAPPED FEB 1st
TAPPED APRIL 1st
TAPPED JUNE 1st
TAPPED AUG 1st
TAPPED OCT 1st
TAPPED DEC 1st
BELOW PANEL
0MM .02 .04 .06 .08 .10 .12 .14 .16 .18 .20 .22 .24 .26 .28 .30 .32 .34 .36 .38 .40MM

FIGURE 4.

VARIATIONS IN BARK THICKNESS IN A SINGLE TREE: A 44/114.

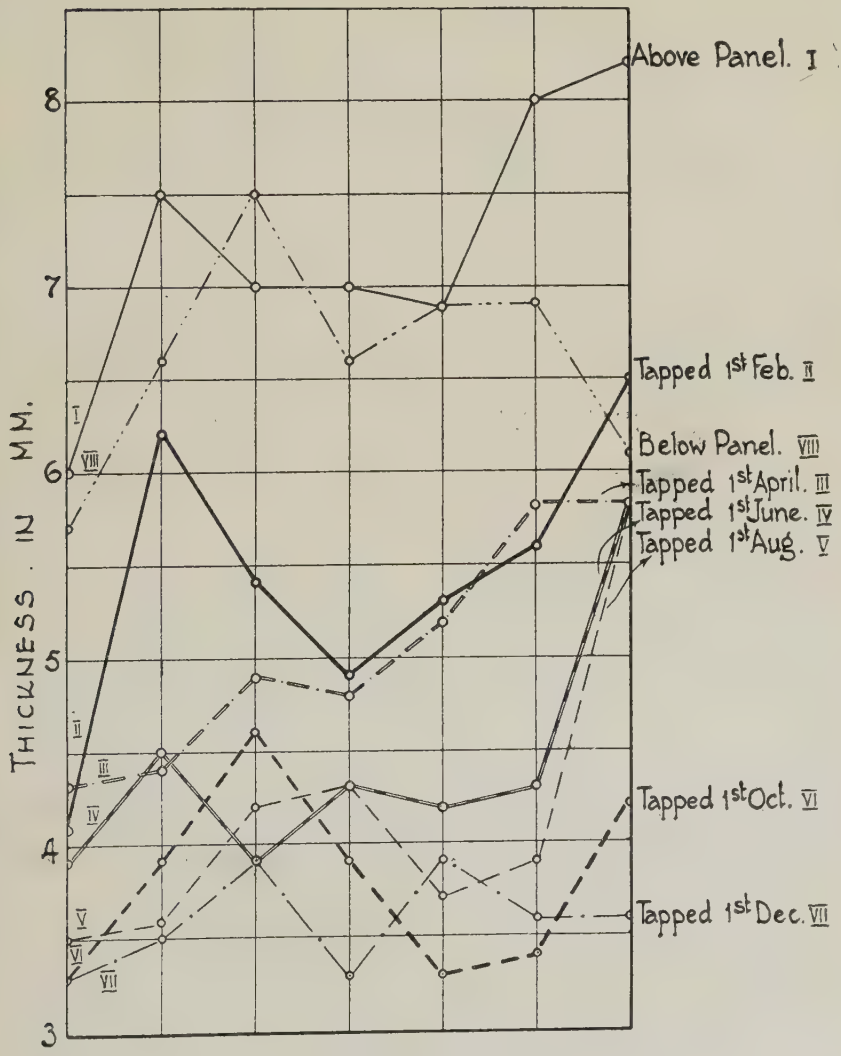


FIGURE 5.

Although in subsequent measurements in another area the present writer found much less divergence, yet he also considers that three readings are necessary to get a fair average.

Another point of interest appeared in one clone only, clone B 58. In eleven sets of readings the average of the set was no greater in January 1929 than it had been from much the same spots in July 1928; one such set appeared in the strip tapped March/April, three sets in the strip first tapped (January/February) and seven in virgin bark: no case occurred in the more recently tapped strips where renewal was still rapid. Seven of the eleven sets referred to appeared in two trees. In spite of this the average thickness for this clone, of which 13 trees were measured, still remains at least as high as the averages of clone B 50.

Conclusions.

Measurements carried out on the virgin and renewed bark of young budded trees of four clones have demonstrated that the bark is adequate for tapping and that renewal is satisfactory so far.

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(3) Heusser, C. (1924). Proeftappingen bij Hevea-oculaties I. Archief voor de Rubbercultuur, **8**, 25-70.

(4) Heusser, C. (1925). Proeftappingen bij Hevea-oculaties II. Ibid **9**, 679-693.

(5) Holder, H.J.V.S. and Heusser, C. (1928). Proeftappingen bij Hevea-oculaties en Zaailingen op de Onderneming Boekit Maradja. Ibid. **12**, 25-49.

THE "DRY RUBBER" CONTENT OF LATEX

FROM

DEEP AND SHALLOW TAPPING.

By

B. J. Eaton and R. G. Fullerton.

The investigations published in this paper were carried out on latex from two adjoining estates belonging to one company, in order to endeavour to account for the low "dry rubber" content of the latex from one of these estates (B).

The rubber from these estates was being sold in the form of latex. The General Manager of the two estates found it frequently difficult on estate B to obtain latex containing the "dry rubber" content laid down in the regulations in connection with the export of latex under the Restriction Enactment and the Customs Regulations. The standard adopted for export of latex from Malaya is 3½ lbs. of "dry rubber" per gallon of latex, i.e., latex plus the ammonia (or any other preservative) added to maintain the latex in a liquid state.

Any lower concentration involves a loss to the estate on the exportable allowance under the Restriction Enactment and also a loss on the export duty payable under the Customs Regulations, both of which are based on the above standard.

The Manager was only able to attribute the lower "dry rubber" content of latex from estate B to the fact that the tapping cut was deeper on estate B than on estate A.

Both estates are situated in the coastal area and the soil consists of a heavy alluvial clay, typical of such areas. On both estates the drainage was similar and good. Tapping systems and other factors were identical as far as could be observed. The trees on estate B are younger than those on estate A, but this would not account for the difference in "dry rubber" content of the latex, which could not be attributed to any factor other than the depth of the tapping cut. This factor also does not affect the result of this investigation which was carried out on both estates.

The estates were visited by one of us (B.J.E.), and the factory books, which were examined over a considerable period, invariably indicated a lower "dry rubber" content of latex on estate B.

In order to ascertain whether the depth of the tapping cut affected the "dry rubber" content of the latex, the Manager carried

out tests on both estates and sent samples of the latex twice a month for a period of one year to the laboratories for determination of "dry rubber" content.

In each case a definite and equal amount of ammonia was added to the same volume of latex, so that the latex should arrive in a liquid state.

The method of tapping, (i.e., whether deep or shallow), was communicated to us after the results of the determination of the "dry rubber" content of the latex had been reported to the Manager.

Results of Investigations.

The following table gives the "dry rubber" content of the ammoniated samples of latex for the period of one year. The figures are expressed in percentages by weight.

Estate.	Field	Date of Tapping.	"Dry Rubber" Content of Latex.	
			Deep Tapping.	Shallow Tapping.
A	B.139	11- 1-27	30.63	35.69
B	B.210	,,	30.14	33.74
A	C.405	18- 1-27	33.12	39.22
B	A.403	,,	30.13	32.12
A	C.410	28- 1-27	33.41	36.13
B	A.403	29- 1-27	34.41	34.84
A	C	10- 4-27	35 20	36.80
B	A	18- 4-27	30.10	30.50
A	B	29- 4-27	33.30	34.90
B	B	,,	29.40	32.45
A	F	8- 5-27	32 90	34.40
B	A	,,	31.70	32.90
A	F	18- 5-27	34.10	34.20
x B	B	19- 5-27	34.40	33.20
x A		27- 6-27	35.19	34.53
x B		26- 6-27	32.55	31.96
A		11- 7-27	35.14	36.41
B		10- 7-27	34.45	35.41
A	C	16- 8-27	39.14	42.22
B	B	15- 8-27	35 08	36.19
A		30- 8-27	38.70	41.06
(a) B		28- 8-27	—	35.39
A	B	15- 9-27	38.59	45.69
x B	B	11- 9-27	37.54	36.77
A	F	30- 9-27	34.68	36.47
B	B	29- 9-27	34.56	35.80
x A	C	10-10-27	38.26	37.87
B	B	11-10-27	35.19	36.59
A	G	31-10-27	37.24	39.51
B	A	,,	36.84	37.11
A	C	10-11-27	37.68	37.63
B	A	,,	33.56	35.19
A	B	20-11-27	37.71	40.23
B	A	,,	32.52	33.78
A		21-12-27	43.28	45.75
B		,,	33.00	34 26
A	A	31-12-27	40.92	43.27
B	A	,,	33.03	34.53

Note (a).—Sample was lost owing to breakage of container.

Remarks and Conclusions.

It will be seen from the above table that, with the exception of five days marked x, the "dry rubber" content of the latex from both estates is greater from shallow than from deep tapping.

Apart from the fact that on both estates, shallow tapping produces a latex of higher "dry rubber" content than deep tapping, it is of interest to note that the "dry rubber" content of the latex on estate B is almost invariably lower than that on estate A. Although the trees on estate B are younger than those on estate A, in both cases they may be considered "mature."

Our thanks are due to Mr. A. B. Carey, General Manager, for carrying out the test tappings, enabling us to make these investigations, and for permission to publish the results.

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THE IDENTIFICATION AND QUANTITATIVE ESTIMATION OF THE YELLOW PIGMENT OF RAW RUBBER.

By

B. J. Eaton and R. G. Fullerton.

It has been frequently observed that rubber latex is on occasions distinctly yellow in colour, and that there is considerable variation in the intensity of the colour of different latices. The colour persists in the raw product when the latex is converted to crepe, but in the case of smoked sheet the tint is masked by the colour of creosotic products absorbed from the smoke on the surface of the sheet, and by the darkening of the sheet as a result of the oxidation which takes place during the smoke-curing process. Even in cases where the latex appears to be white when freshly tapped, crepe prepared from such a latex is generally of a distinctly uniform yellow tint, unless recourse is had to some method for the removal of the colouring matter.

A study of the factors affecting the variation of the intensity of latex colour has not yet been made, but observations indicate that there is to some extent a relation between the colour intensity both of the latex and of the prepared crepe and the age of the tree, in so far as the intensity in most cases seems to be greater in the case of young trees than in the case of more mature stock. Again, the quantity of yellow colouring matter seems to increase for a short time after the wintering season and, when the periodic system of tapping is followed, a very yellow crepe is sometimes obtained for some days after tapping is commenced, following a period of rest. A very considerable variation in the colour intensity of latices obtained from different clones of budded trees has been observed, the colour in some cases ranging from a faintly discernible yellow, to bright canary yellow, and to deep orange.

From the commercial stand-point, the colour of the raw product is at present of importance in the case of sole crepe, since manufacturers demand a very pale product, and even in the case of thin crepe a light colour is preferred by the market. Owing to the great difficulty of "bleaching" the pigment *in situ* by a process at once effective and economical, a somewhat drastic method has been adopted in recent years for the production of a pale sole crepe. The process generally adopted is known as fractional coagulation. Briefly the process consists of the addition to the latex of a quantity of an acid coagulant—formic acid or acetic acid—insufficient to

produce complete coagulation, but sufficient to produce a clot of coagulated rubber which rises to the surface carrying the greater part of the colouring matter with it. This clot is removed by running off from the bottom of the container, through a filter of wire gauze, the remaining uncoagulated latex, which is then coagulated in a separate container by the addition of a further quantity of the acid coagulant, the crepe obtained by this means being of a very pale colour—in some cases almost white. The first clot or fraction is made into thin crepe by the usual processes of machining and drying, and the second fraction is in the same way converted to thin crepe, from which is subsequently built the sole crepe.

This investigation was undertaken with the object firstly of identifying the naturally occurring pigment, and secondly of establishing a satisfactory technique for its quantitative estimation in the latex and in raw crepe rubber. The work to be described is of a preliminary nature, and it is intended to extend it to include an estimation of the pigment content of different latices, and the investigation of the seasonal variation in the pigment content of latex obtained from trees in a particular locality. Again, the problem of finding a suitable substance which can be used economically in factory practice for the bleaching of the yellow pigment is, at least temporarily, of practical importance and requires further attention.

I. Identification of the Pigment.

The raw material used in this investigation was the crepe rubber obtained from the first fraction in the process of fractional coagulation followed on Kirby Estate, Labu, Negri Sembilan for the preparation of sole crepe, and was kindly supplied to the Institute by the Manager, Mr. D. Farquharson. It was considered that this material was particularly well suited to our purpose, since we have observed it to be of an unusually intense yellow colour. Not more than two weeks elapsed between the preparation of the crepe on the estate and its use for the purpose of the following investigation.

Extraction of Pigment.

A quantity of 250 gm. of the crepe was cut into small pieces and dried to constant weight in a vacuum desiccator. The crepe was then divided roughly into two equal portions. One portion was placed in a glass jar fitted with a wide ground-glass stopper and covered with 500 cc. of redistilled acetone. The contents of the jar were shaken at frequent intervals during a period of one

hour or more until all the colouring matter had dissolved in the acetone, leaving the crepe colourless. The acetone solution, which was then a clear golden yellow colour, was decanted into a similar jar containing the other portion of the crepe, and the process of extraction repeated until all the pigment had been extracted. By this method of extraction the use of an inconveniently large volume of acetone was avoided. Moreover, since the extraction was carried out at room temperature and not at the boiling temperature of the solvent in the usual Soxhlet apparatus, the risk of oxidation of the pigment was diminished. In order to obtain sufficient pigment to allow of an examination of its chemical and physical properties, a large quantity of crepe must be used, and this is inconvenient, since it involves the use of a large battery of Soxhlet extractors.

The final acetone solution was then decanted into a Claisen distilling flask and distilled under diminished pressure. The yellow oily residue in the distillation flask was saponified with 100 cc. of 3 per cent ethyl alcoholic potash, the alcohol in which had previously been freed from aldehydes by purification according to the method of Girard and Cuniasse, using powdered m-phenylenediamine hydrochloride. Potassium hydroxide of high purity was used in the saponification mixture. The saponification flask was attached to a reflux condenser and the contents of the flask boiled vigorously on a water-bath for 1 hour until saponification was complete. As a control, 100 cc. of the 3 per cent ethyl alcoholic potash previously mentioned was treated under similar conditions. At the end of this time the contents of the control flask were still colourless. The yellowish-brown contents of the flask containing the pigment, were diluted with 300 cc. of distilled water, cooled, and, after transference to a clean separating funnel, shaken with an equal volume (about 400 cc.) of pure anhydrous ether. Two layers separated—an upper etheric layer of a clear golden yellow colour and a lower alcoholic pale brown layer. The etheric layer was removed by decantation, and the extraction was repeated with fresh volumes of pure ether until no further pigment could be extracted. The combined ether extracts were then washed many times with an excess of distilled water, carefully at first to avoid emulsions, and then more vigorously with subsequent washings, to remove all traces of alkaline soap. The washing was continued until the wash-water no longer gave an alkaline reaction with phenol phthalein indicator. The ether solution was dried by shaking during several hours with neutral fused calcium chloride, filtered off from the drying agent, and evaporated to dryness under reduced pressure. The yellow liquid residue was then dissolved in 200 cc. petroleum ether. The petroleum ether solution was

transferred to a separating funnel and shaken thoroughly with 200 cc. of 90 per cent. methyl alcohol. On standing, two layers separated after a short time. The upper layer remained a clear yellow colour while the lower methyl alcohol layer was colourless. The lower layer was therefore drawn off and discarded, and the petroleum ether solution was washed many times with distilled water to free it from alcohol, dried by shaking with anhydrous calcium chloride, and filtered off from the drying agent. The resulting petroleum ether solution was clear golden yellow. When not in use for the following tests the solution was stored in the dark in an ice-box. This process of extraction and purification of the pigment solution occupied about three days.

Since a preliminary examination of the properties of the pigment suggested very strongly that it was of a carotinoid nature, the technique for its extraction and purification described above was based on this assumption, and is for the most part modelled on methods described by Leroy S. Palmer (1) for the extraction of carotinoids from other biological products.

The presence of sterols in the unsaponifiable matter of the acetone extract of the crepe was proved by means of the colour reactions for sterols described by G. S. Whitby (2). These may be removed from the ether solution of the pigment by means of the digotinin method of Windaus (3), but since, as Palmer points out, this is unnecessary for the examination of the chemical and physical properties of carotinoids, this further purification was not effected.

In order to compare the properties of the petroleum ether solution of the crepe pigment with those of carotin, a petroleum ether solution of the latter was prepared from carrots according to a standard method described by Morrow (4).

The following tests were carried out without any undue delay after the preparation of the petroleum ether solutions of the crepe pigment and of the carrots (carotin control solution).

Properties of Pigment.

A few cubic centimetres of the petroleum ether solution, evaporated to dryness in a small porcelain dish on the water-bath, were used in the solubility tests to be described. On evaporation, residues obtained from the solutions of the crepe pigment and of carrots were both yellow oily liquids with a faint aromatic odour Both solutions were clear golden yellow in colour.

In Table I is given a rough expression of the solubility in various solvents at room temperature.

TABLE 1.

Solvent.	(a) Crepe Pigment.	(b) Carotin Control.	Colour of solution of both a & b.
Water -	Completely insoluble (in hot or cold)	Completely insoluble (in hot or cold)	...
Acetic Acid (glacial) -	Slightly soluble	Slightly soluble	Yellow.
Absolute Methyl Alcohol -	Soluble with difficulty.	Soluble with difficulty.	do.
Absolute Ethyl Alcohol -	do.	do.	do.
Methyl Alcohol (80 per cent.) -	do.	do.	do.
Ethyl Alcohol (80 per cent.) -	do.	do.	do.
Ether (Ethyl) -	Extremely soluble.	Extremely soluble.	do.
Petroleum Ether -	do.	do.	do.
Acetone -	Very soluble	Very soluble.	do.
Carbon Disulphide.	Extremely soluble.	Extremely soluble.	Yellow in dilute solution. Pink to orange in more concentrated solution.

Note.—Both (a) and (b) are soluble in hot dilute alcohol.

On shaking about 20 cc. of a petroleum ether solution of either the crepe pigment or of the carotin control with 20 c.cs. of 92 per cent. methyl alcohol, the alcoholic layer remained colourless, the pigment being retained entirely by the petroleum ether.

On shaking about 20 cc. of a 92 per cent methyl acloholic solution of either the crepe pigment or of the carotin control with an equal volume of carbon disulphide, the latter extracted all the pigment leaving the alcoholic layer colourless. The same results were obtained when petroleum ether was used in place of carbon disulphide. The relative solubility of the pigment in carbon disulphide and methyl alcohol provided very strong evidence of the absence of xanthophylls in the solution of the crepe pigment. The standard method described by Morrow (4), which was followed in the preparation of the control of carotin from carrots, provides for the previous removal of the xanthophylls.

Below is given a resumé of various tests which were applied to the solution of the crepe pigment and of the carotin control.

Test No. 1.—About 10 cc. of the petroleum ether solution was evaporated to dryness on a water-bath, the residue allowed to cool, and a few milligrammes of ferric chloride mixed with the residue by stirring with a glass rod. In both cases a distinct green coloration was imparted to the mixture, the colour being, however, much more intense in the case of the control. The colour in both cases faded slowly on keeping.

Test No. 2.—On adding a small crystal of ferric chloride to about 10 cc. of the petroleum ether solution and shaking, a deep green coloration was obtained in both cases.

Test No. 3.—About 10 cc. of the petroleum ether solution were evaporated to dryness, the residue cooled, and one drop of concentrated sulphuric acid added. In the case of the crepe pigment a transient indigo blue colour was obtained which quickly turned dark brown, and finally almost black. In the case of the control, there was obtained immediately a deep indigo blue colour soon fading to a light grey, without, however, any signs of charring.

Test No. 4.—A little of the petroleum ether solution was evaporated to dryness and the residue dissolved in 95 per cent. ethyl alcohol. On adding a few drops of concentrated sulphuric acid, the solution gradually turned greenish yellow in both cases.

Test No. 5.—Concentrated nitric acid added under the same conditions as in Test No. 4 turned the solution gradually a clear brown colour.

Test No. 6.—Concentrated hydrochloric acid added under the same conditions as in Test No. 4 produced at first hardly any change of colour except a faint greenish tinge, and the colour then faded completely on standing for some time. The same results were obtained in both cases.

Test No. 7.—A sufficient quantity of a strong solution of ammonia added to the solution obtained in Test No. 4 partially restored the original purity of the yellow colour in both cases.

Test No. 8.—A few cc. of the petroleum ether solution was evaporated to dryness and the residue dissolved in 80 per cent. ethyl alcohol. The solution was then boiled with an excess of concentrated sodium hydroxide solution, when it was found that neither in the case of the crepe pigment nor in the case of the control did any apparent change in the intensity of the yellow colour result.

Test No. 9.—About 30 cc. of the petroleum ether solution was evaporated to dryness and the residue was dissolved in a few drops of carbon disulphide. The solution obtained was pink in colour. On progressively diluting with further small quantities of the same solvent the colour changed from pink to orange and finally to golden yellow.

Test No. 10.—Solutions of the crepe pigment or of the carotin control in any of their solvents become colourless when stored exposed to the light at room temperature. In the case of the crepe pigment the yellow colour disappears in about six months, while a solution of the carotin control fades a little more rapidly.

Of the above tests only Nos. 1, 2, 6, 7, 9 and 10 are of value in the identification of carotin since, according to Palmer (1), the other tests referred to above are not characteristic of all carotin solutions. The reduction of ferric chloride to the green ferrous salt in Test No. 1 is of great importance. It was observed that on repeating Test No. 1 with the petroleum ether solution of the control which had been stored for about one week after its preparation, a much less intense green coloration was obtained than that obtained when the test was made with the freshly prepared solution. The intensity of the colour was very similar to that given by the freshly made solution of the crepe pigment, and it is probable that these observed differences were due either to a difference in the concentrations of the solutions or in their purity, i.e. the carotin content of fresh carrots is high whereas, as will be shown later, the content of carotin in crepe rubber is extremely low. Moreover, in the preparation of the solution of the crepe pigment the risk of oxidation is much greater, principally because the process of preparation from the raw material—which in the case of the crepe is rubber latex—requires much longer time for its completion.

In Test No. 3 the charring obtained in the case of the crepe pigment is considered to be due to impurities which were not present in the carotin control.

It is to be noted that in Test No. 6 the colour changes characteristic of the xanthophylls are not obtained, and this affords further evidence of the absence of the latter in the crepe pigment.

Chromatographic Analysis.

The analytical method of Tswett described by Palmer (1) was followed.

A sample of pure calcium carbonate was dried to constant weight by heating in a hot-air oven at a temperature of about 100°C and subsequently cooling in an evacuated desiccator. A glass absorption tube of about 1 to 2 cms. in diameter and 10 to 15 cms. long was then prepared, having one end drawn out to a fine tube of about 1 mm. diameter. A plug of cotton wool was placed in the small end, pressed down tightly, and the tube was then filled with the dry calcium carbonate, which was poured in a little at a time and packed as tightly and evenly as possible with a glass rod. The tube was filled to within about 2 cms. from the top, and a final plug of cotton wool was placed on the top of the absorp-

tion column. The tube was then connected through a small filter flask to a water suction pump, and by means of gentle suction a stream of pure carbon disulphide was passed through the tube until the absorbent was moistened. The suction was then stopped and the cotton wool plug at the top removed. Sufficient of a solution of the crepe pigment in carbon disulphide was then poured into the tube to colour a layer of the absorbent of about 1 cm. depth. This was drawn into the absorbent by gentle suction, and a further quantity of the pure solvent was passed into the tube. The upper part of the tube was kept filled with carbon disulphide, in order to establish by means of suction a continuous stream of the solvent through the column. The pigment solution was observed to pass down the column and the suction was stopped when it had reached the bottom part of the tube. At the end it was noted that the bottom part of the column was rose red in colour while the upper part was pure white, thus showing that no absorption of the pigment by the calcium carbonate had taken place. By continuing the process the pigment was washed completely out of the absorption tube. This test repeated with the carotin control gave identical results.

According to Palmer (1) the above test serves to differentiate the various carotinoid pigments from one another although it does not provide a means for their identification. In the present instance, its chief value lies in supplying additional proof of the presence of only one carotinoid in the crepe pigment.

Additional Tests.

It was found possible to destroy the colour of both the control and the crepe pigment by passing nitrous acid gas—generated in a Van Slyke "amino" apparatus—into the petroleum ether solution. The bleaching was brought about equally well by adding a little sodium nitrite and then dilute hydrochloric acid to the petrol solution. Sulphurous acid was also found to bleach the colour of the petrol solutions of the control and the crepe pigment—as also did hydrogen peroxide, although much more slowly. Chlorine water and bromine water were also found to bleach effectively the petrol solutions.

Conclusions.

The above results show that the natural yellow colouring matter of the crepe rubber used in this investigation is the hydrocarbon pigment carotin. It is of interest to note that according to Palmer (1) there is reason to believe that carotin is closely related to isoprene. It is also relevant to point out that, according to Palmer (1) carotin, when present in the blood serum of certain

mammals, is frequently bound to colloidal serum albumin, and this suggests that carotin in rubber latex may be closely associated with the protein. It should be mentioned that further study may reveal the presence of more than one carotinoid pigment in samples of latex other than the one examined. However, the few samples of different origin which have been examined gave a positive result for carotin and a negative result for xanthophylls.

II. Quantitative Estimation of Pigment.

For the quantitative estimation of the carotin in raw rubber the method followed was based on that of Palmer (1) for the estimation of carotinoids in animal tissues. In outline, the method consists of the extraction of the pigment from a known weight of crepe by means of a suitable solvent, the pigment solution being then diluted with the solvent to a known volume and comparison of its colour made in a Klett colorimeter against a 0.2 per cent. solution of potassium dichromate. Willstatter and Stoll (5) determined the colour value of a solution of potassium dichromate of this concentration in terms of a pure carotin pigment solution by using a 5×10^{-5} molar solution of carotin, equivalent to a solution of carotin of 0.00268 per cent. concentration. They found the following relation to exist between the standard 0.2 per cent. potassium dichromate solution and the solution of pure carotin.

100 mm. depth carotin solution = 101 mm. depth 0.2 per cent. potassium dichromate solution.

50 mm. depth carotin solution = 41 mm. depth 0.2 per cent. potassium dichromate solution.

25 mm. depth carotin solution = 19 mm. depth 0.2 per cent. potassium dichromate solution .

Based on these data Palmer (1) has plotted a curve showing the quantitative relation between the 0.2 per cent. solution of potassium dichromate and the 5×10^{-5} molar solution of pure carotin. Use was made by us of this curve in order to express the colorimeter readings in millimetre depths obtained for the potassium dichromate standard in terms of millimetre depths of pure carotin.

In order, however, to apply the method outlined above to the problem under investigation it was necessary to establish a satisfactory technique, and in so doing various points had to be taken into consideration, such as the method of extraction of the pigment from the crepe, the method of purification of the pigment, and the solvent used for the final colorimetric comparison with the standard. It was therefore decided to compare the results obtained by four different methods as follows. Owing to the great

intensity of the colour of carotin in its various solvents it was decided in each estimation to use a small quantity of the crepe, particularly since the use of large quantities of raw material would render tedious the application of the method to the determination of the carotin content of a large number of different samples. The same crepe rubber as was used in the identification of the pigment was used throughout. The colorimetric comparison of each solution with the standard was made immediately after the solutions had been prepared.

Method (A).—15 grammes of the dried yellow crepe were cut into small pieces, placed in a clean glass jar provided with a ground-glass stopper, and covered with about 50 cc. of redistilled acetone. The contents of the jar were shaken at intervals during a period of about 24 hours until all the pigment had passed into solution, the operation being carried out at room temperature. At the end of the extraction the crepe was colourless, and the acetone solution, which was then a clear golden yellow colour, was decanted into a clean 100 cc. flask, using pure acetone for washing. The solution was made up to 100 cc. with the pure solvent and used directly for comparison with the standard solution in a Klett colorimeter. It was found possible to match the colours satisfactorily, and in order to minimise the possible error introduced by the rapid volatilisation of the solvent, a fresh portion of the solution was used for alternate readings, the average of 9 readings being taken as the final value. The following are the readings obtained—they are typical of those obtained by methods (B), (C), and (D) to be described later.

Colorimeter Readings:

0.2 per cent Potasium Dichromate solution.	Crepe pigment in Acetone
Depth of layer mm.	Depth of layer mm.
4.7	50. 0
4.2	45. 0
3.7	40. 0
3.2	35. 0
2.8	30. 0
3.8	40. 0
5.2	55. 0
3.7	40. 0
4.7	50. 0
Average = 4.0	Average = 42.78

On consulting the graph previously referred to, it was found that 4.8 mm. of a solution of carotin of 0.00268 per cent concentration is equivalent to 4.0 mm. of the potassium dichromate solution. Hence if x is the concentration of the crepe pigment solution;

$$x : 0.00268 = 4.8 : 42.8$$

$$\therefore \quad x = 0.00030$$

$$\text{i.e. carotin in crepe sample} = \frac{0.003 \times 100}{15.00} = 0.0020 \text{ per cent.}$$

or, 2.0 milligrammes carotin in 100 grammes crepe.

Method (B).—15 grammes of the crepe rubber were extracted with redistilled acetone in a Soxhlet apparatus heated on a water-bath until the solvent which siphoned over was colourless. A little of the colourless solvent remaining in the upper compartment containing the crepe was removed, the apparatus immediately re-assembled, and the acetone in the solution of the pigment was distilled off. The flask containing the residue was then cooled and about 10 cc. of petroleum ether was added. The petroleum ether solution of carotin thus obtained contained in suspension small particles of a white substance, which settled to the bottom when the flask and contents were allowed to stand for a short time. The contents of the flask were then filtered through retentive filter paper directly into a clean 50 cc. graduated flask, washing thoroughly with a fresh quantity of the pure solvent. The solution was then cleared by the addition of a few drops of absolute ethyl alcohol and made up to 50 cc. with petroleum ether. This solution was then compared with the dichromate standard in the colorimeter as in method (A), the average readings being 5.3 mm. for the 0.2 per cent potassium dichromate solution and 29.0 mm. for the solution of crepe pigment in petroleum ether. Following the same method of calculation as before, this gives for the percentage of carotin in the sample the value 0.0018 per cent, or 1.8 milligrammes of carotin in 100 grammes of crepe.

Method (C). 15 grammes of the dry crepe were extracted as in method (B) with redistilled acetone in a Soxhlet apparatus heated on a water bath. The bulk of the acetone in the pigment solution was then distilled off in the same apparatus so as to concentrate the solution to low volume and the solution was filtered through a Gooch crucible into a clean filter flask and washed thoroughly with the pure solvent. The contents of the filter flask

were then transferred to a clean dry 50 cc. flask again using pure acetone for washing; after clearing the solution by the addition of a few drops of absolute ethyl alcohol, the contents were diluted to 50 cc. with pure acetone. The solution, which was clear golden yellow, was compared with the standard solution in a colorimeter as in the previous methods, the average readings being 7.0 mm. for the 0.2 per cent potassium dichromate solution and 39.0 mm. for the solution of the crepe pigment. This gives a value of 0.0021 per cent of carotin in the crepe, or 2.1 milligrammes in 100 grammes of the sample.

Method (D). 15 grammes of the crepe were extracted with redistilled acetone in a Soxhlet apparatus as before, the acetone being distilled off in the same apparatus. 10 cc. of 3 per cent ethyl alcoholic potash (alcohol purified according to method of Girard and Cuniasse referred to above) were added to the residue in the distillation flask, which was then fitted to a reflux condenser and the contents were boiled vigorously on the water-bath for about 1 hour. At the end of this time the contents of the flask were pale brownish yellow in colour. The contents were then diluted with 3 volumes (30 cc.) of distilled water, cooled, and transferred to a separating funnel of 100 cc. capacity. An equal volume (40 cc.) of pure ether was then added, the mixture was thoroughly shaken, and allowed to stand. This process was repeated until no appreciable deepening of the yellow colour of the ether layer could be detected. The bulk of the upper ether layer was decanted into a dry flask and a further 20 cc. of ether were poured into the separating flask, and extraction was repeated. It was found that the upper ether layer was colourless, thus showing that all the pigment had been extracted. The lower alcoholic layer was almost colourless and had a faintly discernible brownish tinge. The combined ether extracts were then washed in another separating funnel with distilled water until the water no longer gave an alkaline reaction with phenol phthalein. The ether solution was dried by shaking with a few pieces of neutral fused calcium chloride and decanted into a dry, 100 cc. volumetric flask, using pure ether for washing. The solution was then diluted to 100 cc. with the solvent and colorimetric comparison with the standard made as before. An average reading of 3.7 mm. was obtained for the 0.2 per cent solution of potassium dichromate and 41.0 mm. for the ether solution of the crepe pigment. This gives a value of 0.0019 for the percentage of carotin in the crepe, or 1.9 milligrammes of carotin in 100 grammes of the sample.

The results obtained by the four different methods of procedure are collected in the following table.

Method	Distinguishing features of method	Milligrammes of carotin in 100 grammes of crepe
A.	Extraction in cold—no saponification—solution in acetone. ...	2.0
B.	Hot extraction—no saponification-solution in petroleum ether. ...	1.8
C.	Hot extraction—no saponification—solution in acetone. ...	2.1
D.	Hot extraction—with saponification—solution in ether. ...	1.9

The above results are in close agreement; for convenience of operation, method (A) is the most satisfactory.

If the latex itself is taken as the starting point of a quantitative determination of the carotin content, and it is desired to express the results in terms of the weight of the pigment in weight of latex, essentially the same procedure may be followed That is to say, a known weight of the latex is extracted with acetone by one of the methods referred to above and, with slight modifications, introduced so as to ensure that all the pigment is extracted from the coagulum which forms during the extraction process, the same procedure may be followed. So far, however, we have confined our attention to the pigment content of the raw rubber. In the case of the sample of "first fraction" crepe with which we worked, taking the average of the above results as 0.00195 per cent. an approximation to the value of the pigment content of the latex may be made. Assuming the dry rubber content of the latex to be 35 per cent. and the weight (calculated on the total weight of dry rubber) of the "first fraction" as 20 per cent, the approximate percentage of carotin in the latex is $\frac{0.00195 \times 20 \times 35}{10000} = 0.1365 \times 10^{-3}$, or 0.1 milligramme per 100 grammes of latex.

Summary.

A substance has been found in the unsaponifiable part of the resin of raw rubber possessing properties characteristic of the hydrocarbon pigment carotin.

A technique has been devised for the quantitative determination of the carotin content of crepe rubber giving results in close agreement when determinations are made by different methods of extraction. Owing to the great intensity of the colour of solutions of carotin, it is possible to carry out a determination using a small quantity of the raw material, and a colorimetric comparison of the solution under test with the standard potassium dichromate solution can be made with accuracy and despatch.

Note.

Since this paper was sent for publication, a paper by Dr. A. Frey-Wyssling entitled "Microscopic Investigations on the Occurrence of Resins in *Hevea Latex* has been published (6).

The author states "Nothing could be discovered regarding the composition of the yellow pigment. Some investigators suppose that it is related to a carotinoid, but this could not be confirmed microchemically since no carotin-reaction (blue staining) could be obtained with concentrated sulphuric acid. It is of course possible that the carotin-reaction is hindered by the presence of a lipoid."

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THE PACKING OF RAW RUBBER.

The following requirements of the New York market in regard to the packing of raw rubber are published for the benefit of estates which export their produce to the United States of America. These methods are also recommended generally for rubber exported to other countries.

All rubber must be wrapped in pieces of the same type as the contents of the cases, i.e. pale crepe must be wrapped in lengths of similar pale crepe and smoked sheet in sheets of similar grade to the contents.

All corners and ribs of the cases or bales must be completely covered with the wrapping material so that no splinters or dirt can contaminate the bulk of the contents.

Wrapper sheets count in the weight of the contents and therefore need not be used sparingly. The wrapper sheets, after being brushed, can frequently be used for the manufacture of high grade rubber goods.

Crepe.

The following method is recommended. Each corner rib is covered with a strip of crepe, starting just over half way across the bottom of the case. The strip should be of sufficient length to overlap the top of the case and reach about half way down the outside.

The sides are then covered with similar strips of crepe laid so that the corner strips are partly overlapped.

This method of wrapping is again repeated to form a complete double wrapping.

The crepe forming the main contents is then weighed, placed in the case and pressed in the usual way.

The overlapping strips of crepe are then folded over the top of the contents and the lid is then fixed.

Sheet Rubber.

Since sheet is thicker than the thin crepe prepared in Malaya, one thickness is sufficient. The lower half of the corner ribs are first covered by a sheet. If the fold at the bottom is too thick, the sheet can be cut lengthwise and the two pieces superimposed. The top half of the ribs is treated similarly. The sides are then treated similarly, using two sheets if long sheets are not available.

After the contents have been filled in, pressed and weighed the overlapping wrapper sheets can be folded over in order to cover completely the top of the contents.

In both instances, it is important to note that all the corners as well as the sides of the cases are completely covered with the wrapping by sufficient overlapping of the edges of the wrapper sheets, so that no splinters or particles of dust from the cases can penetrate into the main contents. This outer layer of rubber will also act as a damp-proof wrapping and lessen the tendency to mould development in the rubber enclosed.

Care and attention in packing is important. All cases should be sun-dried. It is often found that the wood of the cases, especially of the corner ribs, is damp, due to the absorption of moisture.

B.J.E.

VEGETATIVE CHARACTERS AND YIELD OF HEVEA.

BY

A. R. Sanderson and H. Sutcliffe.

Three field experiments were carried out to establish the correlation between yield and certain vegetative characters of Hevea. The experiments were numbered 1, 2, and 3.

These experiments were carried out respectively on Pataling Estate (Field 49), on Sungei Way Estate, and on Pilmoor Estate.

A full account of Field Experiment No. 1 appeared in the Quarterly Journal, Vol. 1, Nos. 1 and 2; the present paper is an account of Field Experiments Nos. 2 and 3.

Vegetative Characters and Yield of Hevea.

The possibility of establishing a close correlation between yield and one or more vegetative characters has been the subject of investigation by many workers on Hevea, the final objective being selection of high yielders for propagation purposes.

Whitby (12) and (13) from the examination of 1,011 seven years' old trees in the Federated Malay States, found that the outstanding features of the population were the high co-efficient of variability for yield, and the marked positive skewness of the yield frequency curve. He concluded from this that the presence of an important number of trees, yielding amounts of rubber several times larger than the modal amount, afforded, in proportion to the size of the population, a large mass of material for the profitable exercise of selection.

In the distribution of yield among trees of a normal area of rubber, 9.6 per cent of the trees (trees giving double the mean quantity or more) were yielding on the average 3.6 times as much rubber per tree as the remainder of the trees.

He found that the assumption that a tree with a thicker trunk will give a bigger yield than one with a thinner trunk, was not a sufficient guide for the selection of trees for thinning out to the extent to which it was in use, and that the correlation between girth and yield though positive, did not justify girth being used as the sole criterion for thinning out purposes.

Rutgers (9) concluded that selective thinning must be based on reliable data, that is on the yields of individual trees.

Bobilioff (2) working with 491 trees of mixed parentage investigated the correlation co-efficient between the number of rows

of latex vessels and yield of dry rubber. He found that the frequency curve for the number of rows, was very similar to the one obtained by Whitby for yield, indicating by its skewness that a large number of trees yielding more than the modal amount were available as mother trees or for seed selection. He found a co-efficient of correlation of $+ 0.55 \pm 0.051$ between yield and number of rows of latex vessels in the trees examined

Heusser (6) experimented with 100 trees grown from the seeds of four vigorous and high-yielding mother trees. He found that the daughter trees showed great variation in yield. Although the increase in yield was 16.8 per cent over the old plantings based on equal areas, when based on calculations for individual trees the selected ones gave an increase of 75 per cent. He considers it is desirable in selecting mother trees, that vegetative vigour should go hand in hand with high production. He states, "Thinning out trees based on the number of latex vessel rows "does not yield satisfactory results, this is especially true in "younger plantings. Thinning out trees on the basis of tapping "tests and yield measurements is preferable."

Gehlson (5) carried out experiments in which 4 hectares (10 acres) were thinned out according to latex yield and 4 hectares in accordance with bark examination. The trees were 6 and 7 years old at the beginning of the test. The actual yield over the thinned areas showed no difference between the two methods.

La Rue (7) examined samples of cortex from 955 trees which were 8 years old and of which the yields for over a year were known. He concludes that there is beyond question a high correlation between the yield of a tree and the number of latex vessels in the bark. He considers however that this correlation is not high enough to allow the number of latex vessels alone to be used as a criterion in the selection of high-yielding trees.

He found from 949 trees that while the existing correlation is too low for the girth of the trees alone to be used as a determining factor in thinning, it is high enough to indicate the importance of securing a satisfactory growth increase from year to year. The total results of the correlation indicate the importance of securing a good growth of the trees throughout the whole period of production.

Bryce and Gadd (3) (4) experimented with 161 ten year old trees which were the offspring of Heneratgoda No. 2 tree. From data obtained from these trees, they concluded that there is a decided correlation between the number of latex vessel rows and yield, and that the number of latex vessels has a direct influence on the yield, those trees having the larger number of latex vessel rows normally give greater yields, though they point out that trees with the largest number of latex vessel rows are

not necessarily the highest yielders. In connection with girth and yield they obtained a correlation co-efficient of + 0.582 ± .035 which is much higher than that obtained by most other workers from more mixed populations. They conclude that there is a closer association of girth and yield in offspring of one mother tree than there is in mixed populations. As regards girth and number of rows of latex vessels they consider that greater girth is associated in general with a greater number of latex vessel rows.

Belgrave (1) from experimental work on 106 trees came to the conclusion that selection by girth measurements can hardly be regarded as satisfactory either for thinning or breeding, and that the selection of high-yielders on immature areas by girth measurements is hazardous.

Taylor (10) continued the work started by Bryce and Gadd on the 161 trees, the offspring of Heneratgoda No. 2 tree, and concluded that yield is an inherent quality of the tree, and that a latex vessel row count is of more value in connection with thinning out operations with older trees than with very young trees.

FIELD EXPERIMENT No. 2, SUNGEI WAY ESTATE.

The details of this experiment are practically the same as for Field Experiment No. 1.

The experiment was made on 600 trees, 7 to 8 years old, planted in 1915. These were all untapped trees of very even growth on gently sloping land, the soil being a fairly stiff loam with excellent drainage throughout.

Plugs of cortex were taken at 20 inches only and the girth measurements made at 20 ins. Tapping on a basal V was opened at 20 ins. alternate daily in February 1923 and continued until January 1924. During the period 28 tappings were recorded—dry weights—June 1923 to January, 1924.

As in the previous experiment the tapper's task was small, consisting of 150 trees, and the tappers changed tasks at each successive tapping. Bark consumption was approximately 7 ins. per annum. The cut scrap was included in the records.

The preparation of sections of cortex for counting the number of la ex vessel rows differed from the method used in Field Experiment No. 1 and is described below.

Technique of Preparation of Sections.

1. Numbered plugs from each tree are preserved in picro-formol (Bouin's liquid); these should not be kept too long before using.
2. Moderately thin sections, both longitudinal and transverse,

from each plug are cut and washed well in distilled water to free from preservative as much as possible.

3. Sections from each plug are immersed in distilled water in watch glasses, one or two drops of 1 per cent Osmic acid solution are added, covering to protect from dust.

4. A period of 5 to 20 minutes is allowed for staining until all the sections have become deeply overstained, to make reasonably certain that the coagulated latex in the latex vessels is thoroughly impregnated. When this point is reached the sections should have an almost uniformly black appearance. This is the regressive method and necessitates partial bleaching as described in paragraph 5. As an alternative method the sections may be left in more dilute Osmic acid for the minimum period and examined with a lens from time to time, removed to distilled water as soon as the coagulated latex shows as black lines or black dots, dehydrated and mounted as described later.

5. When thoroughly overstained the sections are passed separately through distilled water into a mixture of 3 grammes potassium chlorate in about 40 c.c. of 50 per cent hydrochloric acid. The sections are rapidly bleached in this solution, bleaching taking place more slowly throughout the coagulated latex in the vessels than in the ground tissue. Care is required at this stage to avoid overbleaching. Bleaching is nearly complete when the sections show only a brown tone.

6. The sections are transferred quickly to distilled water and washed thoroughly to free from acid.

7. When finally washed the coagulated latex should appear as dark brown or black dots (transverse sections) or as dark brown or black lines (longitudinal sections) on an almost white or slightly stained background.

8. The sections are then dehydrated in alcohol and mounted in alcoholic balsam or in Euparal. Xylol or benzene balsam is not suitable.

9. The value of the method lies in the very clear differentiation of the laticiferous system, which enables an accurate count of latex vessel rows to be made quickly, and in addition a permanent record is available at any time for reference or comparison.

10. If considered advisable sections may be counterstained before dehydrating and mounting.

Girth and Number of Latex Vessel Rows at 20 ins.

The correlation coefficient ($+0.40 \pm 0.03$) shows that there is a distinct positive correlation between the two characters, but it

is not sufficiently high to justify the inference that the biggest trees must always have the largest number of latex vessel rows.

The figure obtained does not differ materially from that of Field Experiment No. 1.

Mean number of latex vessel rows at 20 ins.	= 14.3	±0.13
Mean girth at 20 ins.	= 36.8	±0.21
Standard deviation latex vessel rows	= 3.34	±0.09
Standard deviation girth	= 5.32	±0.15
Correlation coefficient	= +0.40	±0.03

YIELD AND GIRTH AT 20 INS.

The correlation coefficient obtained (+0.52 ±0.029) is identical with that for Field Experiment No. 1 and the partial correlation figure, eliminating the influence of the number of latex vessel rows, is +0.4369.

This figure though high is not sufficiently so to justify selection of the highest yielding trees—a very small percentage of the stand — on girth measurements alone.

Mean yield in grammes dry rubber	= 16.1	±0.23
Mean girth at 20 ins.	= 36.8	±0.21
Standard deviation yield	= 7.00	±0.20
Standard deviation girth	= 5.32	±0.15
Correlation coefficient	= +0.52	±0.029

Bryce & Gadd (4) from 161 trees raised from a single high-yielding mother tree obtained a correlation coefficient between yield and girth of +0.582 ±0.035.

The correlation coefficients obtained in these experiments and those obtained by Bryce and Gadd are given in Table 1 below.

TABLE 1.

Correlation Coefficients.

	Field Experiment, No. 1.	Field Experiment, No. 2.	Field Experiment, No. 3.	Bryce and Gadd.
Yield and Girth -	+ 0.52 ±0 033	+ 0.52 ±0.029	+ 0.40 ±0.034	+0.582±0.035
Yield and number of Latex vessel rows -	+ 0.46 ±0.036	+ 0.37 ±0.035	+0.343±0.036	+0.459±0.042
Girth and number of Latex vessel rows -	+ 0.44 ±0.036	+ 0.40 ±0.03	+0.423±0.034	+0.399±0.046

The above table shows the extent of the difference in results for the three field experiments with a mixed population, as compared with the results obtained by Bryce & Gadd with plants raised from seed obtained from a single tree. The differences are so small as to suggest that neither the characters "girth" nor "number of latex vessel rows" are inherent but rather are influenced by external conditions. This suggestion is further strengthened by the coefficients of variability of the characters concerned.

Yield and Number of Latex Vessel Rows at 20 ins.

The correlation coefficient obtained ($+0.37 \pm 0.035$) is rather low, and the partial correlation coefficient $+0.2069$ is much too low to be decisive but sufficiently high to indicate that a large number of latex vessel rows is a desirable character for high-yielding trees.

Mean yield in grammes dry rubber	= 16.1	± 0.28
Mean number of latex vessel rows	= 14.3	± 0.13
Standard deviation yield	= 7.00	± 0.20
Standard deviation number of latex rows	= 3.34	± 0.09
Correlation coefficient	$= +0.37$	± 0.035

Correlation between Cortex thickness and Yield.

For this purpose the thickness of the cortex of all the trees was measured microscopically and included all the tissues from the cambium to the sclerenchyma ring i.e. it was inclusive of all the tissues containing the laticiferous system.

The number of trees (600) was sufficiently large upon which to base conclusions, and the resulting correlation coefficient so small that it could not be considered significant.

Mean cortex thickness	= 5.48	m.m.	± 0.08
Mean yield in grammes	= 446		± 0.80
Standard deviation cortex thickness	= 1.94		± 0.056
Standard yield	= 19.3		± 0.56
Correlation coefficient	$= +0.121$		± 0.04

It was considered useless to continue to investigate this character in connection with Field Experiment No. 3.

Selection of High Yielders.

From the records of the experiment 24 trees were selected after the first tapping period from which to choose possible "mother" trees for budding from at a later date.

Repeat records were made of the selected trees three years later ($10\frac{1}{2}$ years). Details of the results obtained are given in Table 2. below.

TABLE 2.

Record of 24 best yielding trees 1923.

Repeat record of 24 best yielding trees 1926.

Yields are for 28 recorded tappings during each period.

Tree No.	Girth at 20 ins 1923. Age 7½ yrs.	Latex vessel rows 1923 at 20 ins. Age 7½ yrs.	Total yield 1923—1924 grammes dry rubber	Average yield per tapping 1923—1924 grammes dry rubber.	Total yield 1926—1927 grammes dry rubber. Age 10½ yrs.	Average yield per tapping 1926—1927 grammes dry rubber.	Increase or decreased over first year.
C 35	41	20	827	29.5	2000	71.4	+ 41.9
A 53	37	17	830	29.6	1433	51.17	+ 21.5
C 2	44	20	840	30.0	2295	81.96	+ 51.9
C 62	39	15	841	30.0	1840	65.70	+ 35.7
A 100	41	17	842	30.0	1230	43.3	+ 13.3
C 7	44	13	843	30.1	789	28.18	− 2.0
F 28	45	15	843	30.1	937	33.46	+ 3.3
C 70	41	17	847	30.26	765	27.32	− 2.9
C 96	35	20	850	30.35	1612	57.55	+ 27.2
D 49	39	11	853	30.46	1047	37.40	+ 6.9
C 44	37	15	859	30.68	1828	65.28	+ 34.6
D 70	42	18	904	32.28	1458	52.06	+ 19.8
B 13	42	18	961	34.32	1671	59.68	+ 25.3
F 47	45	16	965	34.45	1744	62.27	+ 27.8
F 96	45	22	986	35.22	1537	54.89	+ 19.6
D 84	39	15	991	35.39	1600	57.14	+ 23.8
E 47	47	17	1006	35.92	1172	41.85	+ 5.9
D 40	37	22	1044	37.28	2020	72.14	+ 34.9
B 76	42	18	1067	38.1	1828	65.28	+ 27.1
B 69	55	19	1081	38.60	1419	50.67	+ 12.0
C 97	42	13	1105	39.46	2310	82.5	+ 43.1
D 75	34	12	1169	41.75	1910	68.8	+ 27.1
C 65	39	15	1221	43.64	2104	75.14	+ 31.5
D 97	46	20	1338	47.78	2310	82.5	+ 34.8

It is notable that, although the whole of these trees remained in the high-yielding class, the records for the second tapping period indicate considerable changes in the relative positions of the trees when arranged in order of merit.

With the exception of 4 trees all show a marked increase in average yield per tapping. In some cases the yields were more than doubled at the second test. Tree C 2 which was number 22 in the first test became No. 3 on the second test. All the 24 trees were of more than average girth for the experimental plot.

The first year's records were taken from June 1923 to Jan. 1924. The second year's records were taken from June 1926 to Jan. 1927, when tapping was some 13 ins. lower on the panel.

During part of 1924 the area was taken out of tapping.

Tree C 94 which proved the highest yielding tree during the first year of tapping, yielding at the rate of 35 lbs. of dry rubber per annum for 160 tappings, developed Brown Bast and was excluded from the records.

FIELD EXPERIMENT No. 3, PILMOOR ESTATE.

The area consisted of a block of approximately 8 acres planted in 1916 and contained 600 trees which were divided into 6 series each of 100 trees, designated, series A to F. The land was almost uniformly flat and the growth of the trees was even.

No thinning out, apart from diseased trees, had been done previous to starting the experiment.

Plugs of cortex were taken from each tree during September 1924 at 20 ins from ground level for the latex vessel row count.

The method of preparing sections for determining the number of latex vessel rows in the cortex was the same as that used in Field Experiment No. 2.

Girth measurements in inches were made of all trees during October 1924.

Tapping was opened in November 1924, alternate daily on a V cut at 20 ins. The length of cut was 18 ins. (two 9 in. arms of V) on each tree regardless of size of tree. This length of cut (18 ins.,) was approximately half the average girth of the trees, and hence in the aggregate was approximately equal in length to a V on half the circumference. After each tapping the latex was coagulated in the cups, the coagulum collected and rolled, then thoroughly dried as crepe samples, and finally weighed to the nearest gramme.

Amount of bark removed.

The total bark removed during the first twelve months' tapping averaged a fraction over 6 inches per tree and varied

from 5.75 ins., to 7.2 ins. This must be considered moderate, in fact it is rather on the low side.

For the three years' tapping the total bark removed amounted to 20 ins.

As regards depth of tapping, the only limit imposed was absence of wounds.

The records for the first year includes 20 tappings spread evenly over the period, Nov. 1st 1924 to October 31st 1925.

During the 2nd year, Nov. 1st 1925 to October 31st 1926, 24 tappings were recorded, and a further 24 records were made between Nov. 1st 1926 and October 31st 1927. In each case the records were distributed evenly over the period. During the early part of December 1926 75 trees were removed on a yield basis, leaving a final stand of 524 trees for the 3rd year of the experiment.

Number of Latex Vessel Rows and Girth at 20 ins.

The correlation coefficient obtained ($+0.423 \pm 0.034$) agrees very well with the figures from the two previous experiments and admits of no different conclusions.

Mean number of latex vessel rows	= 13.1	± 0.12
Mean girth at 20 ins.	= 37.0	± 0.26
Standard deviation number of latex vessel rows	= 2.95	± 0.08
Standard deviation girth	= 6.38	± 0.28
Correlation coefficient	$= +0.423$	± 0.034

Yield and Girth at 20 ins. (1st year's tapping).

The correlation coefficient obtained ($+0.40 \pm 0.034$) differs considerably from the results of Field Experiments Nos. 1 & 2, being smaller than either. It may be interpreted as more or less a measure of the unreliability of the factor girth in determining yield, but at the same time it must be remembered that a cut of constant length was used, regardless of size of tree. This new factor must have had some bearing on the results as compared with the previous experiments.

Mean yield per tree per tapping	= 17.0	grammes	± 0.31
Mean girth at 20 ins.	= 37.0	ins.	± 0.25
Standard deviation yield	= 7.51		± 0.21
Standard deviation girth	= 6.38		± 0.28
Correlation coefficient	$= +0.40$		± 0.034

A first impression would be that the trees of large girth would be considerably affected adversely as regards yield by the smaller cut while the smaller girth trees would be affected oppositely. Closer investigation suggests that this is not strictly true. According to Bobilioff "Investigations concerning the origin of latex of *Hevea brasiliensis*" (Archief voor de Rubbercultuur No. 3. Vol. 5, March 1921). "In the ordinary course of tapping, latex "is withdrawn not only from a region below the cut but also "from a part of the cortex about 5 cms. wide at each extreme "end of the cut, i.e. latex is withdrawn from the cortex from "an area some 4 ins. wide in addition to the length of cut and "this is constant, regardless of length of cut." From this it is obvious that the results obtained from ½ cuts compared with 1/3rd cuts cannot be expected to be proportional to length of cut but must always fall considerably below the calculated figure.

In the present experiment with cuts of equal length for all trees and throughout the tapping panels, all the trees were reduced to equality so far as length of cut was concerned and a truer result was obtained regarding the correlation of yield and girth.

Yield and Girth, 3rd Year's Tapping.

The girth measurements were taken at 20 ins., during August 1927.

The correlation coefficient differs by 0.08 from the figure obtained for the result of the 1st year, so there is no significant difference at the end of the 3rd year.

Mean yield per tree per tapping	= 23.2 grammes	±0.423
Standard deviation yield	= 9.68	±0.299
Mean girth	= 40.3 ins.	±0.434
Standard deviation girth	= 3.53	±0.299
Correlation coefficient	= +0.322	±0.04

The following tables show that, on average, the trees of large girth yield more per tree per tapping than the smaller trees. It is important to note here that this result is not influenced by length of cut, since that remained constant at 18 ins., regardless of size of tree and is not affected by position in the panel. Hence it follows that the big trees are yielding more on average per unit length of cut.

TABLE 3.

Field Experiment No. 3.

1st Year's Tapping.

Average yield per tree per tapping of trees arranged in girth groups from Appendix No. 1.

Girth in inches.	Number of trees.	Average yield per tree per tapping in grammes.
20-25	14	10.3
26-30	92	12.4
31-35	141	15.4
36-40	179	17.5
40-45	123	20.5
46-50	34	20.8
50-55	16	23.3
	599	

TABLE 4.

Field Experiment No. 3.

3rd Year's Tapping.

Average yield per tree per tapping of trees arranged in girth groups. Figures from Appendix No. 1.

Girth in inches.	Number of trees.	Average yield per tree per tapping in grammes.
20-26	7	14.5
26-32	66	15.3
32-38	114	17.8
38-44	164	19.9
44-50	118	22.5
50-56	41	26.5
56-62	10	25.0
62-68	4	24.1
	524	

Yield and Number of Latex Vessel Rows at 20 ins.

The correlation coefficient obtained ($+0.343 \pm 0.036$) is substantially similar to that for Field Experiment No. 2 and the partial correlation figure is ± 0.2079. This figure is too low to suggest the use of the single character, number of latex vessel rows, for selection of a small percentage of high yielders, for use as mother trees. It is, however, sufficiently high to indicate that a large number of latex vessel rows is a desirable character in selected high yielding trees.

Mean yield per tree per tapping	= 17.0	grammes	± 0.31
Mean number of latex vessel rows	= 13.1		± 0.12
Standard deviation yield	= 7.51		± 0.21
Standard deviation number of latex vessel rows	= 2.95		± 0.08
Correlation coefficient	$= +0.343$		± 0.036

Correlation of Yield during Successive Years.

The correlation coefficient obtained ($+0.9003 \pm 0.0066$) is very high, sufficiently so to justify the assumption that the good yielders of one year remain in general the good yielders during the successive year, but it does not necessarily follow that the highest yielders of one year remain the highest yielders of the successive years. (See Appendix 1).

Mean yield per tree per tapping	1st year	= 17.02	grammes	± 0.31
Mean yield per tree per tapping	2nd year	= 21.27	,,	± 0.36
Standard deviation yield	1st year	= 7.48		± 0.22
Standard deviation yield	2nd year	= 9.03		± 0.26
Correlation coefficient		$= +0.9003$		± 0.007

The correlation coefficient for yields of the 2nd and 3rd years' tapping ($+0.708$) shows a considerable decrease compared with the figure for the 1st and 2nd years, but is still much higher than the figures for yield and girth, or yield and number of latex vessel rows.

Mean yield per tree per tapping	2nd year	= 22.8	grammes	± 0.393
Mean yield per tree per tapping	3rd year	= 23.2	,,	± 0.423
Standard deviation yield	2nd year	= 9.03		± 0.279
Standard deviation yield	3rd year	= 9.63		± 0.299
Correlation coefficient		$= +0.708$		± 0.022

For the 1st and 3rd years' tappings the coefficient of correlation is still lower, but the influence of the interval of one year has to be taken into account.

A further factor affecting this is possibly the removal of 75 trees thinned out on a yield basis in December 1926, reducing the stand to 524 trees.

Mean yield per tree per tapping	1st year	= 19.4	grammes	±0.180
Mean yield per tree per tapping	3rd year	= 23.20	,,	±0.423
Standard deviation yield	1st year	= 7.905		±0.244
Standard deviation yield	3rd year	= 9.68		±0.423
Correlation coefficient		= +0.498		±0.033

From table 5 showing average characters for each series of 100 trees the greatest progress is shown by the poorest group (Series 6).

In the three years the average yield per tree per tapping for this group increased from 11.1 to 14.3 grammes. This, however, is somewhat discounted by the fact that 75 trees were thinned out in December 1926 and of these over 50 were from this series. These were the poorest yielders.

A better comparison is between the successive years 1924-1925 and 1925-1926 during which period the stand of trees remained constant.

During that period the poorest yielding groups showed the greatest percentage increase on average.

From Series 1 to Series 6 the average yield per tree per tapping showed a steady increase from 16.3 per cent in Series 1 to 38.7 per cent in Series 6. None of the groups show a decrease in average yield per tree per tapping.

It should be noted, however, that Series 1 shows a slight decrease in average for the 3rd year compared with the 2nd but none showed a very marked increase in the third year over the 2nd year, when compared with the 3rd year increase over the 1st year.

Examination of columns (a), (b), (c) Table 5 shows that all the series retained their original positions throughout the three years' tapping, i.e. the order of merit in the 1st year remained the same throughout the 3rd year.

In yield distribution the figures for the first year's tapping differ considerably from the results obtained by Whitby.

TABLE 5.

Field Experiment No. 3.

Average Characters Table. Girth at 20″. Latex vessel rows at 20″ and yield (1924-1925) (1925-1926) (1926-1927) for six series of 100 trees arranged in order of merit for yield for 1st year's tappings.

Series	Average yield per tree per tapping 1924-1925 grammes. (a)	Average yield per tree per tapping 1925-1926. (grammes.) (b)	Percentage increase (b) over (a)	Average yield per tree per tapping 1926-1927 grammes (c)	Percentage increase (c) over (a)	Average number Latex vessel rows.	Average girth at 20 ins 1924 (inches)	Number of trees 1924-1925 (d)	Number of trees 1926-1927 (e)
1	30.6	35.6	16.34	33.8	10.4	14.5	41.2	100	100
2	21.1	24.8	17.54	25.4	20.4	13.6	37.8	100	98
3	17.3	22.2	28.32	23.4	37.0	13.7	38.2	100	98
4	13.9	18.1	30.21	19.2	38.1	13.0	36.5	100	96
5	11.2	14.8	32.15	17.0	51.78	12.3	35.6	100	96
6	8.0	11.1	38.73	14.3	78.74	11.2	32.5	99	46
	17.0	21.1		23.2		13.0	37.0	599	524

Ten per cent of the trees—the first 60 trees in Series 1 average character Table No. 5—gave 19.4 per cent of the total crop or nearly ten per cent less than Whitby found. At the opposite end of the table, the last 60 trees of Series 6—10 per cent of the total trees—gave 4.2 per cent of the total crop, a considerably higher figure than that found by Whitby.

During the first year of tapping the 10 per cent highest yielders gave an average 2.2 times as much as the remainder and the 10 per cent poorest yielders produced an average 0.38 times as much per tree as the remainder.

The same trees were compared for the second year of tapping and the 10 per cent highest yielders gave on average 2.0 times as much as the remainder. While the 10 per cent poorest yielders produced on average 0.45 times as much as the remainder.

During the third year and after removal of 75 poorest yielders the relative figures were similar to those for the 2nd year.

Correlation between Increase in Yield per tapping 1925-1926 and Number of Latex Vessel Rows 1924.

The correlation coefficient obtained (+0.1133) is much too low to be significant and indicates that the trees with a large number of rows and small yield for the first year have not improved their relative positions as regards yield during the succeeding years, or in other words the poor yielders have remained poor, regardless of the number of latex vesssl rows.

Mean increase in average yield per tree per tapping 1925-1926	= 4.18 grammes	±0.16
Mean number of latex vessel rows 1924	= 13.10	±0.12
Standard deviation increase in yield per tree per tapping 1925-1926	= 3.90	+0.15
Standard deviation number of latex vessel rows	= 2.93	±0.85
Correlation coefficient	= +0.113	±0.04

Obviously then it is undesirable to mark trees for retention on a latex vessel row basis in the expectation that the yields will improve accordingly.

The coefficient of variability for increase in average yield per tapping is very high, indicating that considerable variations occur. These are most marked among the high yielding class, there being far less variation amongst the low yielders.

TABLE 6.

Field Experiment No. 3.

Pilmoor Estate.

Average yield per tree per tapping for selected trees yielding at the rate of more than 10 lbs. per tree per annum for 160 tappings.

Tree No.	Girth in inches at 20 ins.	Number of latex vessel rows at 20 ins.	Average yield per tapping in grammes dry rubber for 20 tappings. Nov. 1924—Oct. 1925.	Average yield per tapping in grammes dry rubber for 24 tappings. Nov. 1925—Oct. 1926.	Total percentage increase or decrease in 2nd year.	Average yield per tapping in grammes dry rubber 24 tappings. Nov. 1926—Oct. 1927	Total percentage increase or decrease in yield 3rd year compared with 2nd year.
A 4	41	10	29.6	23.8	— 19.6	15.4	— 35.3
B 23	41	15	29.6	38.5	+ 30.0	19.9	— 48.3
D 22	44	17	30.5	32.1	+ 5.2	29.8	— 7.1
B 90	41	17	31.1	39.0	+ 25.4	49.9	+ 27.9
C 47	40	13	32.2	51.5	+ 60.0	18.1	— 64.8
C 16	41	18	32.2	33.8	+ 5.0	28.9	— 14.5
A 49	42	12	32.9	49.6	+ 50.0	55.6	+ 12.1
A 38	37	16	33.0	40.4	+ 22.4	35.5	— 12.1
A 12	43	14	33.0	52.1	+ 67.0	57.5	+ 10.3
C 39	42	27	33.3	48.5	+ 45.6	57.9	+ 19.3
C 8	43	15	33.8	42.6	+ 26 0	50.5	+ 18.5
E 99	39	17	35.7	35.4	— .8	36.4	+ 2.8
D 66	42	17	39.2	50.1	+ 27.8	59.9	+ 19.5
A 55	41	18	39.9	48.0	+ 20.3	39.9	— 16.9
E 73	38	14	41.0	35.3	— 13.8	28.9	— 18.1
C 97	40	13	43.5	61.7	+ 41.8	60.2	— 2.4
A 28	45	15	44.4	56.4	+ 27.0	41.0	— 27.3
B 100	45	24	46.7	51.2	+ 9.6	32.3	— 36.8
C 14	38	12	47.5	41.3	+ 13.0	24.9	— 40.0
C 81	47	17	56.0	64.5	+ 15.2	62.1	— 3.7
A 33	51	12	62.5	65.4	+ 4.6	67.9	— 3.8
Av: 21 trees	42	15.9	38.4	45.8	+ 20.7	41.5	— 10.1

There is a general tendency for the gap between the high and low yielding classes to increase in successive years. (See Table 5). In comparing column (c) with (a), it must be remembered that of the 75 trees removed 50 were from Series 6 and 14 from Series 5 and these were the lowest yielders. Considering this fact the percentage increase (c) over (a) for these two series is easily understood.

Selected Trees.

A list of 21 selected high yielders on the first year's records together with the records of these for the 2nd and 3rd years is given. (Table 6).

The table contains details of trees which are the prospective "mother" trees.

It will be noted that only 4 of the 21 trees show a decrease in yield per tapping for the second year as compared with the first year and the amount of decrease with the exception of A.4 is not substantial. While the relative positions of the poorest and best yielders of this group remain constant the remainder have altered position considerably.

The variation in yields is in some cases remarkable, e.g. C.47, A.12, C.39, C.97, A.49, and to date (December 1927) none of these high yielding trees have shown signs of Brown Bast. It should be noted that tapping is on a basal V of 18 ins. length alternate daily, which for these large girth trees is in every case less than half the circumference, and in the case of the biggest trees is approximately one-third of the circumference.

For the first year's tapping the selected trees yielded at the rate of 1,354 lbs. per acre per annum with 100 trees per acre and 160 tappings per annum, and for the second year 1,615 lbs. per acre per annum under the same conditions, an increase of 261 lbs. per acre per annum equivalent to 19.28 per cent. During the 3rd year, a decrease from the 2nd year is noted, the calculated yields per acre per annum being 1,456 lbs.

TABLE 7.

Correlation Coefficients Summarised.

	Field Experiment No. 1. 68 Tappings.	Field Experiment No. 2. 28 Tappings.	Field Experiment No. 3. 20 Tappings.
Yield and Girth at 20 ins ...	+ 0.52 ± 0.029	+ 0.52 ± 0.029	+ 0.40 ± 0.034 (1924)
			+ 0.322 ± 0.040 (1926)
Yield and latex vessel rows at 20 ins ...	+ 0.46 ± 0.036	+ 0.37 ± 0.035	+ 0.343 ± 0.036
Latex vessel rows and girth at 20 ins ...	+ 0.44 ± 0.036	+ 0.40 ± 0.03	+ 0.423 ± 0.034
Yield 1st year and yield 2nd year ...	—	—	+ 0.90 ± 0.006
Yield 1st year and yield 3rd year ...	—	—	+ 0.498 ± 0.033
Yield 2nd year and yield 3rd year ...	—	—	+ 0.708 ± 0.022

The summary of results in Table 7 shows the comparatively small differences in results from the three experiments for the same pairs of characters.

It is interesting to note the similarity of the figures for girth and yield in Field Experiment No. 3 for the 1st and 3rd year's tappings.

TABLE 8.

Table of Coefficients of Variability.

	Field Experiment No. 1.	Field Experiment No. 2.	Field Experiment No. 3.
Yield ...	56.50	43.47	44.17 (1924-1925) 41.96 (1925-1926)
Girth ...	16.89	14.79	16.69
Latex Vessel Rows	26.00	23.36	22.52
Thickness of Cortex.	—	35.40	—

From the table of coefficients of variability it is seen that throughout the experiments the character "girth" shows consistently the lowest figure by far, the number of latex vessel rows coming next in order, while the figure for thickness of cortex is considerably higher than either of the two other characters. For all characters except yield in the three experiments the coefficients agree very well with the figures obtained by other investigators. The coefficient of variability for yield is much higher than the figure obtained by Bryce and Gadd.

Discussion of the Results of the Experiments.

(a) In the three field experiments definite positive correlations have been established between:—

(i) Yield and girth.
(ii) Yield and number of latex vessel rows.
(iii) Number of latex vessel rows and girth.
(iv) Yield of one year with that of another year.
(v) Yield and thickness of cortex.

(b) The correlation coefficients for the same two characters show comparatively small differences in the three experiments. They are so nearly alike that, taken in conjunction with results obtained by other investigators, the relationships between the different pairs of characters may be accepted as definitely established.

(c) The correlation coefficient for yield of one year with that of another is highest in value of the characters examined, and so much higher than the others that definite and final conclusions can be drawn. See para (g).

For successive years the figure is higher than for years separated by an interval. This perhaps agrees with expectations, since the longer the period between the years correlated the greater the chance for changes in comparative yields to take place.

(d) Although in general the good yielders of one year remain good yielders, this is not necessarily true except as applied to classes, each consisting of a considerable number of individuals.

It is very significant of classes as a whole. Unfortunately the experiment was not carried on for a sufficiently long period to obtain data from the renewed cortex.

(e) Three years is not too long a period for yield tests to be made with a view to budding if the best results are to be gained as regards selection of a very small percentage of the stand for mother trees.

(f) Thickness of cortex alone is not very useful as an indication of yield.

(g) Yield tests alone are likely to give satisfactory results in the choice of a very small percentage of the stand for "mother" trees and these tests should be carried out over a sufficiently long period. The amount of dry rubber should be determined.

Whilst it is admitted that the determination of dry rubber entails more work and care than determination of volume by inspection or measure, it is much preferable to the volumetric determination of latex. This need only be applied after the preliminary tests which should eliminate the great majority of the trees. (See table of percentage dry rubber, Field Experiment No. 1. Appendix 3).

(h) From Field Experiment No. 3 where the cut has the same length throughout the area in tapping and throughout the panel, the fact that the greater average yield of the large girth trees taken as groups is independent of the length of cut is established. This agrees with Heusser (6) who states that in selecting "mother" trees, vegetative vigour should go hand in hand with high production, and it is also in agreement with La Rue (7) who notes the importance of securing a satisfactory growth increase from year to year.

APPENDIX No. 1.

Field Experiment No. 3.

The following list contains a complete record of all the trees for three successive years' tappings.

For the first year the trees are arranged in order of merit according to average yield per tapping in grammes dry rubber.

Comparison with the second and third years' figures shows considerable variation, but examination of the fourth column—number of latex vessel rows at 20 ins. indicates that the suggestion that there is any definite influence from this character is without foundation (Table 9). The correlation coefficient for increase in yield per tapping and number of latex vessel rows is small and suggests that no good purpose can be served by retaining trees on a bark examination basis alone.

TABLE 9.

Field Experiment No. 3.

Pilmoor Estate.

Records for 3 years' tapping.

Tree Number.	Average yield per tapping in grammes, dry rubber.			Number of latex vessel rows at 20 ins. Oct. 1924.	Girth at 20 ins. 1924.	Girth at 20 ins. 1927.
	1st year Nov. 1924—Oct. 1925.	2nd year Nov. 1925—Oct. 1926.	3rd year Nov. 1926—Oct. 1927.			
A 33	62.4	65.4	67.9	12	51	54
C 81	56.0	64.5	62.2	17	47	47
B 4	47.7	43.4	56.0	13	36	37
C 14	47.5	41.3	24.4	12	38	38
B 100	46.7	51.2	32.3	24	45	47
A 28	44.4	56.4	41.0	15	45	51
C 97	43.4	61.7	60.2	13	40	45
D 10	41.9	51.4	50.6	14	38	46
E 73	41.0	35.4	29.0	14	38	39
A 55	39.8	48.0	39.9	18	41	45

Tree Number	Average yield per tapping in grammes, dry rubber.			Number of latex vessel rows at 20 ins. Oct. 1924.	Girth at 20 ins. 1924.	Girth at 20 ins. 1927.
	1st year Nov. 1924—Oct. 1925.	2nd year Nov. 1925—Oct. 1926.	3rd year Nov. 1926—Oct. 1927.			
D 66	39.4	50.1	60.0	17	42	45
D 60	36.3	44.1	46.0	15	54	58
D 98	36.0	32,1	29.3	16	54	55
A 38	36.0	40.4	35.5	16	37	39
E 3	35.8	36.7	40.5	17	47	50
E 99	35.7	35.4	36.4	17	39	41
E 44	34.3	40.6	49.7	11	41	44
C 79	34.2	39.5	37.2	18	34	35
C 8	33.8	42.6	50.5	15	43	48
F 61	33.5	37.5	47.0	15	44	46
C 39	33.3	48.5	53.4	27	42	50
D 90	33.2	31.6	21.2	12	34	36
A 12	33.0	52.1	57.5	14	43	53
A 49	33.0	49.6	55.5	12	42	47
B 1	32.9	34.0	29.4	12	39	41
F 94	32.9	33.2	15.0	12	32	34
D 7	32.8	37.7	36.1	21	45	48
C 25	32.8	27.2	25.0	10	38	39
C 16	32.4	33.7	29.0	18	41	46
C 47	32.2	51.5	23.1	13	40	41
D 52	32.1	41.1	39.5	12	36	43
E 100	31.4	41.1	38.0	14	34	34
A 3	31.3	50.0	49.9	11	43	46
B 90	31.1	39.0	44.9	17	41	42

Tree Number.	Average yield per tapping in grammes, dry rubber.			Number of latex vessel rows at 20 ins. Oct. 1924.	Girth at 20 ins 1924.	Girth at 20 ins. 1927.
	1st year Nov. 1924—Oct. 1925.	2nd year Nov. 1925—Oct. 1926.	3rd year Nov. 1926—Oct. 1927.			
F 60	30.6	33.3	30.5	20	39	39
D 22	30.5	32.1	30.0	17	44	47
B 14	30.5	33.6	39.8	12	37	42
E 60	30.5	28.6	21.3	16	30	31
E 98	30.4	33.4	29.0	15	32	32
C 78	30.3	43.0	46.7	16	46	47
A 4	29.6	23.7	15.7	10	41	46
B 23	29.6	38.5	19.4	15	42	44
F 67	29.5	33.1	29.7	11	41	46
D 49	29.3	32.4	30.0	14	43	50
A 53	29.1	42.7	37.6	17	40	46
B 70	29.1	34.7	31.3	16	40	42
B 31	28.9	36.4	34.7	20	41	45
E 67	28.6	28.2	24.0	16	40	41
D 84	28.5	33.2	37.3	17	49	53
A 81	28.2	27.8	25.2	14	32	34
B 55	28.1	37.7	37.7	15	50	53
C 28	28.1	40.8	45.0	12	46	51
A 63	28.1	38 4	36.9	15	38	41
F 12	28.0	30.4	31.0	17	38	42
D 38	27.9	32.8	23.2	19	44	45
E 64	27.8	26.3	27.0	15	43	44
B 32	27.7	30.5	26.8	14	40	42
E 20	27.7	30.5	29.0	13	41	48

Tree Number.	Average yield per tapping in grammes, dry rubber.			Number of latex vessel rows at 20 ins. Oct. 1924.	Girth at 20 ins. 1924.	Girth at 20 ins. 1927.
	1st year Nov. 1924— Oct. 1925.	2nd year Nov. 1925— Oct. 1926.	3rd year Nov. 1926— Oct. 1927.			
C 4	27.6	30.9	35.4	18	35	38
B 65	27.6	33.5	39.5	15	42	49
B 87	27.6	33.4	13.7	14	41	44
C 7	27.5	32.0	40.1	15	44	44
A 8	27.4	36.2	42.2	13	40	43
F 48	27.4	31.5	35.0	16	43	46
D 12	27.0	27.0	19.8	16	46	54
D 64	26.7	28.5	28.0	12	41	41
F 80	26.6	32.7	33.4	14	49	49
E 34	26.6	19.9	12.0	12	55	60
B 28	26.6	32.1	33.0	10	44	49
F 9	26.4	28.6	34.3	16	44	44
A 14	26.2	38.1	29.9	12	36	38
A 7	26.0	32.8	32.6	12	36	41
A 74	26.0	29.3	31.2	11	38	45
B 91	25.9	33.9	27.0	10	35	36
D 69	25.9	35.5	35.2	14	52	58
D 35	25.9	30.8	32.6	13	53	55
F 14	25.7	30.5	27.0	13	37	42
F 52	25.7	29.4	33.0	13	42	47
A 59	25.6	28.9	34.2	15	32	39
B 68	25.5	31.0	37.9	17	43	50
E 32	25.5	21.4	20.0	13	34	36
A 34	25.4	29.5	31.8	14	46	52

Tree Number.	Average yield per tapping in grammes, dry rubber			Number of latex vessel rows at 20 ins. Oct. 1924.	Girth at 20 ins. 1924.	Girth at 20 ins. 1927.
	1st year Nov. 1924—Oct. 1925.	2nd year Nov. 1925—Oct. 1926.	3rd year Nov. 1926—Oct. 1927.			
C 10	25.3	31.7	38.0	13	38	38
D 25	25.3	37.7	41.2	16	48	51
D 19	25.3	31.4	32.0	17	49	53
F 38	25.2	30.9	26.1	12	39	43
E 65	25.1	22.1	12.5	14	37	39
C 52	25.1	40.5	39.4	11	50	51
D 34	25.1	31.8	20.6	14	41	45
C 80	25.0	42.3	45.0	15	44	46
A 17	24.9	23.3	24.9	16	31	39
D 36	24.8	31.5	21.7	13	42	45
F 88	24.7	24.7	28.4	14	35	39
A 39	24.6	31.1	26.2	12	44	47
B 16	24.4	17.6	5.2	11	39	39
A 85	24.3	25.4	26.6	9	35	39
F 95	24.3	29.0	17.4	12	33	34
F 49	24.2	26.8	30.0	14	41	49
C 33	24.1	29.3	23.0	12	40	44
C 99	24.1	30.6	35.6	13	37	43
F 24	24.1	21.9	9.0	12	43	46
B 5	24.0	26.4	36.2	11	32	37
C 20	24.0	23.5	18.5	17	35	36
B 59	23.6	36.4	39.5	14	47	54
D 53	23.5	24.4	21.4	16	35	37
B 96	23.5	24.6	18.9	18	40	42

Tree Number.	Average yield per tapping in grammes, dry rubber.			Number of latex vessel rows at 20 ins. Oct. 1924.	Girth at 20 ins. 1924.	Girth at 20 ins. 1927.
	1st year Nov. 1924— Oct. 1925.	2nd year Nov. 1925— Oct. 1926.	3rd year Nov. 1926— Oct. 1927.			
A 92	23.4	24.0	37.9	15	38	42
D 85	23.3	28.9	32.9	10	42	44
C 70	23.2	35.3	43.6	9	38	39
B 3	23.1	33.3	56.0	11	44	49
E 77	23.1	29.1	23.4	11	41	43
F 84	23.1	28.3	45.0	9	39	39
C 51	23.0	22.0	22.7	11	32	33
B 94	22.9	24.4	22.3	14	35	36
B 40	22.9	23.6	19.4	17	40	42
A 40	22.8	31.1	30.9	13	41	45
A 50	22.8	29.8	27.6	12	37	42
D 81	22.8	21.4	25.5	19	43	45
C 54	22.7	32.5	27.0	15	47	49
D 73	22.5	19.1	18.3	17	44	44
E 66	22.5	25.5	30.4	18	44	48
E 81	22.5	28.3	29.4	9	30	32
F 79	22.4	31.1	31.8	14	41	44
D 89	22.4	29.0	25.0	11	42	43
F 26	22.3	24.8	21.4	15	42	45
D 97	22.3	26.2	25.3	17	44	46
C 94	22.2	30.4	35.4	10	37	38
F 3	22.2	21.0	20.0	11	31	32
F 36	22.1	24.1	—	12	40	—
E 58	22.0	22.8	23.4	14	30	31

Tree Number.	Average yield per tapping in grammes, dry rubber.			Number of latex vessel rows at 20 ins. Oct. 1924	Girth at 20 ins. 1924.	Girth at 20 ins. 1927.
	1st year Nov. 1924 – Oct. 1925.	2nd year Nov. 1925— Oct. 1926.	3rd year Nov. 1926— Oct. 1927.			
D 70	21.9	25.3	35.4	16	45	50
B 76	21.6	20.4	24.6	13	33	34
A 82	21.6	32.1	26.5	13	30	33
D 31	21.6	23.4	26.0	14	33	36
E 14	21.6	18.2	13.4	15	45	50
E 52	21.6	18.3	28.8	13	36	38
E 21	21.5	19.9	21.6	15	42	42
C 6	21.5	19.1	17.5	20	34	36
A 75	21.4	23.3	22.0	15	35	37
A 88	21.4	21.6	20.6	16	38	40
B 84	21.4	26.3	31.2	15	34	36
D 18	21.4	39.6	40.5	14	53	62
A 72	21.3	26.6	20.9	16	54	62
A 22	21.2	16.1	25.6	11	39	44
F 69	21.2	23.6	27.4	13	42	45
F 62	21.1	20.4	20.5	18	40	40
E 74	21.1	26.2	24.0	13	39	43
E 12	21.1	22.8	33.4	14	52	59
A 24	21.0	26.1	27.7	12	39	42
A 42	21.0	18.0	10.8	15	30	31
E 26	21.0	17.3	18.4	19	44	48
F 74	21.0	28.1	23.7	19	44	44
D 62	20.8	24.1	27.8	14	36	42
A 2	20.8	32.1	36.9	15	53	63

Tree Number.	Average yield per tapping in grammes, dry rubber.			Number of latex vessel rows at 20 ins. Oct. 1924.	Girth at 20 ins. 1924.	Girth at 20 ins. 1927.
	1st year Nov. 1924—Oct. 1925.	2nd year Nov. 1925—Oct. 1926.	3rd year Nov. 1926—Oct. 1927.			
B 33	20.8	21.2	23.3	14	37	42
B 67	20.7	25.4	27.2	11	44	46
E 88	20.7	26.8	26.0	15	52	60
B 42	20.6	22.0	9.7	12	38	39
D 54	20.5	28.6	33.5	17	51	55
A 23	20.4	24.2	28.9	13	39	49
E 95	20.4	18.8	21.1	12	24	26
A 26	20.4	26.9	39.9	10	27	28
D 11	20.4	25.7	27.8	20	38	39
C 2	20.3	23.8	—	12	32	—
B 37	20.2	27.7	28.2	13	34	40
A 30	20.1	24.2	14.5	10	34	38
C 29	20.1	23.5	19.7	14	30	31
F 28	20.1	22.7	19.3	8	30	31
F 68	20.1	19.5	19.1	19	38	38
F 73	20.1	20.0	27.3	16	33	36
A 9	20.0	23.5	18.2	7	31	31
B 77	19.9	25.0	30.4	14	34	34
D 24	19.9	21.5	21.8	11	28	29
F 41	19.9	28.6	16.5	15	44	50
F 50	19.9	18.3	20.6	10	35	39
A 89	19.8	23.5	29.0	12	37	41
F 35	19.8	21.7	24.4	15	48	49
B 6	19.7	22.5	24.2	14	42	47

Tree Number.	Average yield per tapping in grammes, dry rubber.			Number of latex vessel rows at 20 ins. Oct. 1924.	Girth at 20 ins. 1924.	Girth at 20 ins. 1927.
	1st year Nov. 1924—Oct. 1925.	2nd year Nov. 1925—Oct. 1926.	3rd year Nov. 1926—Oct. 1927.			
A 71	19.7	30.0	32.6	11	36	37
C 85	19.7	21.9	19.5	12	38	40
D 65	19.7	26.4	21.0	14	39	41
E 63	19.7	20.4	19.0	12	30	31
E 29	19.6	26.4	35.0	11	43	52
F 71	19.6	32.4	17.5	12	39	40
F 92	19.6	32.4	24.9	16	31	34
C 35	19.5	19.7	17.9	10	27	28
A 58	19.5	25.0	19.5	16	37	49
C 90	19.5	25.3	25.4	15	30	31
C 17	19.4	29.8	32.3	15	50	52
B 95	19.4	20.0	24.4	11	30	31
E 17	19.4	20.0	21.4	10	32	44
A 25	19.3	27.0	22.8	12	32	35
D 40	19.2	23.1	21.0	18	41	46
F 33	19.2	20.4	22.0	10	45	47
D 100	19.2	24.3	29.2	19	40	41
F 82	19.2	28.9	31.2	15	42	44
A 41	19.1	24.2	21.8	13	47	52
D 59	19.1	16.3	23.5	11	34	34
F 75	19.1	25.0	26.3	17	43	44
E 59	19.0	25.9	17.0	14	45	47
E 76	19.0	21.7	26.2	12	40	40
B 11	18.9	15.4	7.7	14	28	28

Tree Number.	Average yield per tapping in grammes, dry rubber.			Number of latex vessel rows at 20 ins. Oct. 1924.	Girth at 20 ins. 1924.	Girth at 20 ins. 1927.
	1st year Nov. 1924— Oct. 1925.	2nd year Nov. 1925— Oct. 1926.	3rd year Nov. 1926— Oct. 1927.			
C 45	18.9	27.4	17.1	16	38	39
E 79	18.9	20.2	27.0	16	34	37
C 12	18.8	24.3	24.0	10	38	41
A 48	18.8	22.0	22.9	12	34	45
B 49	18.8	16.0	14.8	14	33	35
B 66	18.7	27.7	27.4	12	38	40
E 5	18.6	15.2	13.0	14	40	41
B 26	18.6	25.0	17.8	16	42	45
A 10	18.5	29.0	27.4	9	38	43
A 52	18.5	25.6	26.6	16	37	46
F 37	18.5	21.4	22.0	13	43	49
B 61	18.4	23.3	26.0	16	35	38
D 20	18.4	26.3	22.1	20	45	48
B 39	18.3	25.2	25.5	14	39	45
C 69	18.3	29.8	31.0	14	39	41
B 81	18.3	20.2	19.0	16	40	43
E 25	18.3	21.9	20.6	16	47	53
E 40	18.3	23.0	25.5	13	36	38
B 58	18.2	22.0	25.4	14	36	38
C 48	18.2	24.2	60.0	17	39	40
F 25	18.2	21.9	24.0	15	38	41
F 72	18.1	30.2	32.2	15	43	44
D 96	18.1	25.0	23.4	13	44	49
C 41	18.0	23.8	18.0	14	42	43

Tree Number	Average yield per tapping in grammes, dry rubber.			Number of latex vessel rows at 20 ins. Oct. 1924.	Girth at 20 ins. 1924.	Girth at 20 ins. 1927.
	1st year Nov. 1924—Oct. 1925.	2nd year Nov. 1925—Oct. 1926.	3rd year Nov. 1926—Oct. 1927.			
D 30	18.0	26.4	19.8	11	30	32
E 48	18.0	19.4	18.6	15	47	49
E 97	18.0	20.9	19.8	15	28	29
C 36	17.9	21.5	25.5	19	38	39
D 55	17.9	25.8	21.2	14	36	39
B 18	17.8	16.3	19.0	13	32	33
D 9	17.8	21.4	24.0	16	43	48
E 39	17.8	21.7	27.1	12	44	46
F 89	17.8	25.2	17.9	15	27	31
C 13	17.7	28.6	36 0	14	49	50
A 13	17.6	30.7	29.4	12	40	44
B 21	17.6	25.1	16.0	21	43	46
B 89	17.6	21.9	28.0	12	36	36
E 80	17.6	24.2	23.0	11	37	40
B 51	17.5	24.4	28.7	18	38	41
E 89	17.5	20.3	21.0	16	40	41
E 49	17.4	16.5	19.0	10	41	41
B 52	17.4	16.1	11.6	15	39	39
B 60	17.4	27.0	26.2	15	37	41
F 29	17.4	6.1	—	14	40	—
F 70	17.4	27.5	25.4	14	38	39
E 38	17.3	20.9	22.0	16	43	48
A 16	17.3	28.2	33.7	13	40	50
B 12	17.3	19.9	21.2	15	43	47

Tree Number.	Average yield per tapping in grammes, dry rubber.			Number of latex vessel rows at 20 ins. Oct. 1924.	Girth at 20 ins. 1924.	Girth at 20 ins. 1927.
	1st year Nov. 1924— Oct. 1925.	2nd year Nov. 1925— Oct. 1926.	3rd year Nov. 1926— Oct. 1927.			
B 25	17.3	19.9	—	11	31	—
C 68	17.3	23.2	24.0	11	44	47
F 76	17.3	24.5	27.2	22	44	46
D 76	17.2	18.9	18.0	14	39	41
B 86	17.2	20.5	17.9	15	40	43
D 4	17.2	22.2	21.5	13	30	31
F 40	17.2	16.6	17.2	14	38	40
E 50	17.2	20.4	19.7	10	40	42
C 32	17.1	20.9	12.5	16	32	41
A 29	17.0	20.0	20.9	13	37	37
A 25	17.0	24.1	21.9	10	31	33
B 43	17.0	19.1	20.3	7	39	39
C 88	17.0	26.1	24.0	12	26	28
D 5	17.0	25.1	31.3	17	44	50
D 28	17.0	22.1	23.4	11	37	40
F 27	17.0	25.9	30.7	11	36	39
F 7	16.9	16.9	16.2	11	31	33
B 30	16.7	21.0	28.0	14	44	45
E 15	16.6	19.3	19.6	19	53	53
A 83	16.5	23.4	17.5	11	44	48
C 96	16.5	27.5	27.6	8	45	47
E 69	16.5	18.7	26.0	14	30	32
A 97	16.4	22.7	27.4	12	46	51
E 19	16.4	21.3	19.0	16	50	53

Tree Number.	Average yield per tapping in grammes, dry rubber.			Number of latex vessel rows at 20 ins. Oct. 1924.	Girth at 20 ins. 1924.	Girth at 20 ins. 1927.
	1st year Nov. 1924— Oct. 1925.	2nd year Nov. 1925— Oct. 1926.	3rd year Nov. 1926— Oct. 1927.			
C 63	16.3	24.3	42.7	17	50	56
D 56	16.3	19.3	22.4	10	30	41
F 91	16.3	28.4	24.1	9	30	31
C 91	16.2	26.1	23.2	18	34	44
D 37	16.2	19.8	15.7	14	39	42
C 9	16.1	22.7	30.0	14	46	50
C 31	16.1	26.3	25.1	14	32	32
A 79	16.1	16.2	20.5	14	38	40
E 23	16.1	15.0	19.0	11	30	32
D 45	16.0	18.3	22.0	10	39	43
E 62	16.0	24.1	33.2	14	33	36
E 84	15.9	21.8	22.0	10	40	41
C 19	15.9	21.0	24.8	11	34	40
B 34	15.9	26.6	28.6	14	38	43
B 38	15.9	24.3	28.4	15	42	45
A 76	15.9	20.0	21.1	16	34	34
C 73	15.8	21.4	28.0	15	44	47
E 16	15.8	17.6	19.7	13	35	40
E 28	15.8	19.5	20.1	10	36	39
F 59	15.8	21.3	24.1	13	48	52
C 56	15.7	24.0	20.1	12	30	28
C 84	15.7	21.9	20.4	12	31	44
B 50	15.6	25.0	29.8	15	33	35
D 32	15.6	19.6	16.0	12	37	39

Tree Number.	Average yield per tapping in grammes, dry rubber.			Number of latex vessel rows at 20 ins. Oct 1924	Girth at 20 ins. 1924.	Girth at 20 ins. 1927.
	1st year Nov. 1924 – Oct. 1925.	2nd year Nov. 1925— Oct. 1926.	3rd year Nov. 1926— Oct. 1927.			
E 54	15.6	17.0	20.7	15	45	46
F 11	15.5	19.9	21.5	11	34	35
F 78	15.5	16.9	17.0	12	24	24
B 15	15.4	23.0	29.3	13	43	47
F 86	15.4	21.2	23.3	18	30	33
B 9	15.3	15.5	16.0	9	28	28
B 71	15.3	17.7	17.8	15	37	38
F 16	15.3	24.0	18.1	16	33	35
D 33	15.3	18.8	26.5	14	37	38
D 71	15.3	19.5	15.6	13	38	39
D 42	15.2	22.0	18.0	12	33	36
D 47	15.2	22.1	29.0	13	40	41
F 51	15.2	14.8	18.7	18	39	40
D 15	15.2	17.0	18.3	7	39	39
C 64	15.1	21.5	19.4	12	44	48
D 77	15.1	16.1	22.1	14	34	35
B 80	15.0	16.4	19.5	10	33	34
D 27	15.0	20.8	18.1	12	41	42
F 42	15.0	16.5	15.0	14	40	43
E 72	15.0	16.6	23.0	12	34	34
F 77	14.8	17.8	19.8	11	38	41
C 26	14.8	22.6	18.2	11	38	42
C 60	14.8	20.5	19.8	14	42	44
A 70	14.8	21.7	24.4	20	41	45

Tree Number.	Average yield per tapping in grammes, dry rubber.			Number of latex vessel rows at 20 ins. Oct. 1924.	Girth at 20 ins. 1924.	Girth at 20 ins. 1927.
	1st year Nov. 1924— Oct. 1925.	2nd year Nov. 1925— Oct. 1926.	3rd year Nov. 1926— Oct. 1927.			
E 8	14.8	21.4	24.8	18	41	46
E 30	14.8	14.5	15.2	8	30	33
A 98	14.7	16.0	15.4	20	36	37
C 95	14.7	24.2	17.5	11	40	42
B 57	14.6	20.9	18.5	14	37	41
D 39	14.6	21.4	20.7	15	35	37
B 10	14.5	18.9	22.0	15	32	47
B 27	14.5	14.5	16.0	14	37	40
A 77	14.5	17.2	18.7	15	32	34
C 62	14.5	20.7	22.2	12	40	44
E 13	14.5	18.0	—	12	39	—
C 57	14.3	20.9	23.8	13	47	51
D 51	14.3	18.3	23.7	18	35	37
B 29	14.2	18.2	21.1	12	39	45
C 40	14.2	18.5	20.9	15	32	35
D 17	14.2	16.6	16.7	14	36	36
D 68	14.2	17.8	16.2	10	31	34
A 67	14.1	19.9	23.1	16	40	46
B 75	14.1	18.8	21.4	15	35	38
D 86	14.1	16.3	19.2	16	49	51
E 90	14.1	17.1	20.2	7	49	52
F 47	14.0	19.9	20.4	11	41	43
A 11	13.9	20.9	23.0	10	38	48
B 63	13.9	16.2	18.5	14	36	37

Tree Number.	Average yield per tapping in grammes, dry rubber.			Number of latex vessel rows at 20 ins. Oct. 1924	Girth at 20 ins. 1924.	Girth at 20 ins. 1927.
	1st year Nov. 1924 - Oct. 1925.	2nd year Nov. 1925— Oct. 1926.	3rd year Nov. 1926— Oct. 1927.			
C 67	13.9	21.0	21.6	11	39	40
A 100	13.9	16.0	17.1	11	33	33
E 4	13.9	18.1	20.5	10	40	44
D 41	13.8	16.6	15.4	14	43	46
E 55	13.8	17.0	16.2	15	37	38
E 6	13.7	16.3	18.7	21	55	58
A 43	13.7	16.6	14.5	12	58	66
A 86	13.7	16.0	14.9	10	33	39
C 98	13.7	3.5	—	12	30	—
F 4	13.7	15.2	7.5	12	32	37
F 8	13.7	17.6	19.6	9	32	34
C 83	13.7	16.0	29.3	10	32	32
C 22	13.6	18.8	18.6	16	44	46
C 50	13.6	23.8	25.9	14	35	36
A 87	13.6	15.9	17.3	12	23	24
A 93	13.6	25.2	14.2	15	34	44
B 83	13.6	15.8	14.7	9	29	31
E 92	13.6	17.0	—	13	46	—
A 19	13.5	7.8	—	12	34	—
D 92	13.5	13.2	19.8	12	44	49
F 81	13.4	22.6	21.2	14	36	38
B 97	13.4	18.1	10.0	14	35	35
C 82	13.4	22.7	19.3	14	41	42
D 8	13.4	14.0	18.0	13	37	38

Tree Number.	Average yield per tapping in grammes, dry rubber.			Number of latex vessel rows at 20 ins. Oct. 1924.	Girth at 20 ins 1924.	Girth at 20 ins. 1927.
	1st year Nov. 1924— Oct. 1925.	2nd year Nov. 1925— Oct. 1926.	3rd year Nov. 1926— Oct. 1927.			
E 37	13.4	17.9	18.7	17	42	44
D 46	13.4	21.1	22.2	16	44	44
E 10	13.3	13.1	13.8	11	41	42
F 10	13.3	19.8	20.4	10	36	39
D 26	13.3	16.6	18.2	13	36	40
E 53	13.3	17.8	18.4	13	35	38
F 64	13.2	13.7	13.5	14	42	47
A 15	13.1	25.2	26.0	11	32	35
B 56	13.1	15.3	16.5	13	33	34
C 75	13.1	16.9	15.4	14	34	34
F 100	13.1	16 7	20.6	13	30	30
B 47	13.0	18.7	22.5	9	38	40
C 44	13.0	20.9	23.0	13	39	43
D 78	13.0	14.0	14.0	13	31	35
C 5	12.9	19.8	17.9	16	42	47
C 37	12.9	20.5	22.0	22	41	47
C 87	12.9	19.4	19.9	14	31	33
D 14	12.8	24.2	22.5	14	32	36
D 91	12.8	14.6	13.0	10	30	31
C 18	12.7	15.0	13.2	6	27	27
B 41	12.7	18.9	15.5	13	45	49
C 92	12.7	19.2	17.3	9	39	39
D 1	12.7	20.7	30.5	10	34	39
E 68	12.7	16.0	19.5	14	40	48

Tree Number.	Average yield per tapping in grammes, dry rubber.			Number of latex vessel rows at 20 ins. Oct. 1924.	Girth at 20 ins. 1924.	Girth at 20 ins. 1927.
	1st year Nov. 1924—Oct. 1925.	2nd year Nov. 1925—Oct. 1926.	3rd year Nov. 1926—Oct. 1927.			
E 71	12.7	14.4	17.3	14	32	37
E 83	12.7	18.0	19.2	12	36	40
E 94	12.7	14.2	15.0	10	26	27
A 5	12.6	16.7	22.2	12	34	38
A 20	12.5	17.1	20.8	9	29	32
F 87	12.5	13.8	12.0	14	26	29
E 9	12.6	15.3	20.2	12	30	34
D 67	12.6	20.3	23.6	16	55	61
E 22	12.6	15.2	17.6	16	47	52
A 1	12.5	21.3	15.4	14	40	49
A 18	12.5	16.6	19.2	16	45	47
B 8	12.5	16.0	19.5	10	32	34
B 19	12.5	16.4	15.8	15	34	38
C 21	12.5	15.6	17.0	10	39	44
F 19	12.5	9.6	12.4	12	30	33
C 1	12.4	18.4	20.4	13	33	33
B 46	12.4	15.3	15.7	11	32	35
B 85	12.4	13.7	16.3	13	42	44
E 57	12.3	14 6	17.0	14	34	36
F 57	12.3	13 2	16.1	14	34	34
F 85	12.3	14.8	12.0	9	30	30
A 57	12.2	12.2	18.2	14	35	38
C 46	12.2	16.3	20.4	15	43	50
C 71	12.2	18.0	13.9	11	35	36

Tree Number.	Average yield per tapping in grammes, dry rubber.			Number of latex vessel rows at 20 ins. Oct. 1924.	Girth at 20 ins 1924.	Girth at 20 ins. 1927.
	1st year Nov. 1924—Oct. 1925.	2nd year Nov. 1925—Oct. 1926.	3rd year Nov. 1926—Oct, 1927.			
F 39	12.2	17.5	19.5	15	45	49
F 90	12.2	16.2	14.0	10	30	31
D 29	12.1	10.3	8.6	12	30	32
C 65	12.0	16 1	18.7	12	33	34
A 61	11.9	17.9	18.5	8	30	35
A 78	11.9	14.5	22.1	15	32	35
A 84	11.9	17.1	27.2	7	35	38
F 98	11.9	15.6	21.0	13	32	37
C 23	11.8	21.2	28.4	10	36	40
A 69	11.8	15.7	18.4	14	37	41
A 73	11.8	14.0	23.4	12	49	57
F 2	11.8	12.4	12.2	10	26	28
D 44	11.8	12.5	16.3	15	32	34
D 57	11.8	10.1	10.2	13	37	41
F 65	11.8	15.8	14.9	17	40	40
E 93	11.8	14.1	15.2	7	26	26
F 83	11.8	17.0	17.3	14	26	30
E 56	11.7	13.9	16.5	14	30	30
F 21	11.6	13.2	15.8	13	25	29
D 99	11.5	13.5	12.6	8	29	29
A 45	11.4	14.7	14.4	13	45	52
C 72	11.4	16.5	17.3	15	39	40
F 56	11.4	17.8	21.2	18	44	46
B 54	11.3	14.8	13.5	11	30	30

Tree Number.	Average yield per tapping in grammes, dry rubber.			Number of latex vessel rows at 20 ins. Oct. 1924.	Girth at 20 ins. 1924.	Girth at 20 ins. 1927.
	1st year Nov. 1924— Oct. 1925.	2nd year Nov. 1925— Oct. 1926.	3rd year Nov. 1926— Oct. 1927.			
A 6	11.2	19.8	23.2	13	37	45
B 17	11.2	16 6	18.5	10	37	42
C 55	11.2	21.9	13.4	15	47	50
E 18	11.2	12.6	10.7	12	29	33
B 24	11.1	12.7	15.8	10	26	27
C 43	11.1	17.2	21.8	16	41	46
A 65	11.1	12.6	12.3	11	26	26
F 17	11.1	15.4	—	11	33	—
D 83	11.1	20.3	14.7	13	40	42
E 96	11.1	16.7	22.6	9	37	39
A 27	11.0	17.7	17.3	11	38	45
A 44	11.0	13.5	12.2	14	32	32
C 58	11.0	20.4	20.2	16	30	36
E 1	11.0	14.4	14.4	14	40	47
F 13	11.0	10.0	—	9	24	—
B 48	10.9	16.3	14.7	13	43	45
C 100	10.9	23.9	23.4	14	28	31
D 3	10.9	14.0	16.2	16	38	39
D 72	10.9	13.5	18.2	16	37	41
F 66	10.9	14.3	15.7	16	36	38
C 34	10.9	16.5	22.6	9	38	39
B 45	10.9	14.7	14.8	15	37	38
D 43	10.8	14.9	13.6	14	42	46
C 3	10.8	12.6	—	10	27	—

Tree Number.	Average yield per tapping in grammes, dry rubber.			Number of latex vessel rows at 20 ins. Oct. 1924.	Girth at 20 ins. 1924.	Girth at 20 ins. 1927.
	1st year Nov. 1924—Oct. 1925.	2nd year Nov. 1925—Oct. 1926.	3rd year Nov. 1926—Oct. 1927.			
B 73	10.7	15.6	16.5	10	47	50
C 15	10.7	16.8	16.1	14	43	45
C 66	10.7	16.0	13.6	13	41	39
B 82	10.7	11.1	—	12	25	—
D 74	10.7	15.1	14.2	13	31	31
D 80	10.7	12.3	13.5	15	36	37
F 93	10.7	14.8	14.4	11	30	32
B 62	10.6	10.2	—	14	32	—
C 38	10.5	14.4	15.4	11	47	47
A 64	10.5	11.3	8.7	13	30	31
C 30	10.5	17.1	18.5	8	35	37
B 88	10.5	12.9	44.2	13	37	40
B 92	10.5	16.0	18.3	16	38	42
F 30	10.5	12.6	—	8	37	—
E 42	10.5	10.6	13.6	8	35	36
B 13	10.5	13.6	13.5	9	32	34
F 6	10.4	13.5	16.1	13	30	30
F 22	10.4	17.1	19.2	11	27	31
B 69	10.4	14.9	14.9	10	42	46
F 45	10.3	12.5	13.0	8	33	37
A 51	10.3	11.1	—	12	27	—
A 60	10.3	14.7	16.8	12	35	36
E 51	10.2	12.1	15.6	9	36	36
A 68	10.2	13.1	15.5	13	33	35

Tree Number.	Average yield per tapping in grammes, dry rubber.			Number of latex vessel rows at 20 ins Oct. 1924.	Girth at 20 ins. 1924.	Girth at 20 ins. 1927.
	1st year Nov. 1924— Oct. 1925.	2nd year Nov. 1925— Oct. 1926.	3rd year Nov. 1926— Oct. 1927.			
E 86	10.1	11.7	—	13	30	—
C 59	9.9	2.4	—	10	33	—
D 2	9.9	10.5	—	12	36	—
F 20	9.9	10.7	—	10	32	—
D 63	9.9	14.8	14.7	14	34	35
B 64	9.8	10.5	—	12	35	—
C 74	9.8	17.1	—	13	37	—
A 91	9.8	22.9	15.5	9	28	31
B 93	9.8	11.6	10.0	11	32	36
D 5	9.8	15.1	17.2	13	29	31
E 7	9.8	13.2	17.4	12	31	33
A 37	9.8	12.3	20.6	10	45	53
D 95	9.7	11.5	—	13	35	—
B 22	9.7	12.4	25.12	12	34	36
F 5	9.7	10.6	—	14	33	—
E 31	9.7	10.8	10.5	12	36	42
E 36	9.7	12.0	14.6	12	44	48
F 53	9.7	11.1	13.3	12	35	36
F 43	9.6	10.5	—	10	40	—
F 54	9.6	15.3	16.4	15	36	38
A 66	9.5	12.9	14.0	12	33	33
C 77	9.5	13.3	—	11	23	—
F 23	9.5	11.3	12.8	11	29	33
E 41	9.5	10.3	—	7	24	—

Tree Number.	Average yield per tapping in grammes, dry rubber.			Number of latex vessel rows at 20 ins. Oct. 1924.	Girth at 20 ins. 1924.	Girth at 20 ins. 1927.
	1st year Nov. 1924— Oct. 1925.	2nd year Nov. 1925— Oct. 1926.	3rd year Nov. 1926— Oct. 1927.			
E 43	9.5	11.0	—	9	28	—
E 47	9.5	12.0	11.6	11	34	38
A 54	9.4	11.3	13.7	8	30	32
F 44	9.4	13.7	15.0	11	29	30
F 58	9.4	10.3	—	18	33	—
B 78	9.3	12.9	15.6	8	36	38
C 86	9.3	15.9	16.4	18	38	38
E 33	9.3	12.9	14.2	7	26	29
B 79	9.2	9.5	13.0	14	35	41
C 89	9.2	15.0	—	11	20	—
D 88	9.2	10.2	—	16	28	—
B 35	9.1	13.9	18.0	12	40	47
C 27	9.1	13.4	—	10	32	—
C 61	9.1	18.9	15.1	15	30	39
E 24	9.1	12.6	18.7	10	26	27
D 75	9.1	16.3	20.5	9	37	43
B 98	8.9	12.9	15.5	10	38	42
D 58	8.9	12.5	13.6	12	38	43
B 7	8.8	14.2	14.0	11	32	33
B 36	8.8	10.0	—	9	32	—
C 42	8.8	12.0	19.1	12	37	37
A 94	8.8	12.0	—	10	30	—
E 45	8.8	11.3	16.2	11	32	32
E 11	8.7	10.3	—	7	29	—

Tree Number	Average yield per tapping in grammes, dry rubber.			Number of latex vessel rows at 20 ins. Oct. 1924.	Girth at 20 ins. 1924.	Girth at 20 ins. 1927.
	1st year Nov. 1924— Oct. 1925.	2nd year Nov. 1925— Oct. 1926.	3rd year Nov. 1926— Oct. 1927.			
E 75	8.7	10.4	—	12	36	—
D 21	8.6	13.4	15.0	11	33	36
F 32	8.6	10.0	13.4	9	30	31
A 21	8.5	11.3	—	12	27	—
F 31	8.5	9.1	—	12	25	—
D 94	8.4	9.1	—	16	31	—
C 49	8.3	16.4	17.1	11	41	43
A 80	8.3	14.6	14.4	11	38	41
C 76	8.3	16.8	19.4	11	34	40
A 96	8.3	17 6	23.4	19	50	57
D 23	8.3	14.5	19.0	15	31	33
F 63	8.3	13.0	12.9	16	38	42
A 36	8.2	10.7	15.7	13	42	43
A 99	8.2	10.2	—	16	34	—
B 20	8.1	7.6	—	11	33	—
E 27	8.1	12.0	10.7	14	40	40
D 87	8.1	14.5	19.7	10	36	39
B 74	8.0	7.2	—	9	27	—
E 70	8.0	10.5	15.1	14	26	31
F 99	8.0	11.0	—	14	26	—
A 56	7.9	9.4	—	12	43	—
B 53	7.9	9.0	—	9	33	—
D 50	7.9	12.0	15.0	13	35	37
C 24	7.8	11.5	—	9	41	—

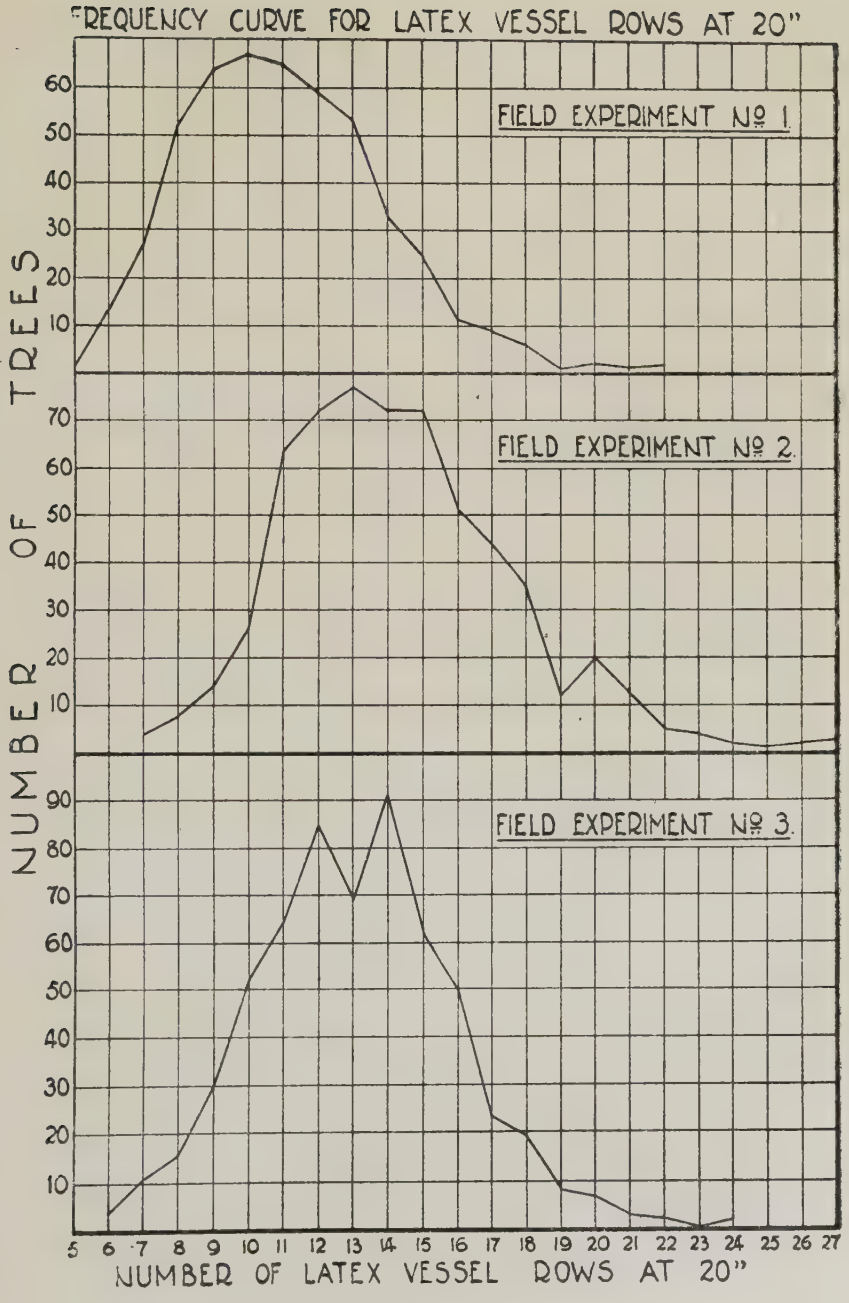
Tree Number.	Average yield per tapping in grammes, dry rubber.			Number of latex vessel rows at 20 ins Oct. 1924.	Girth at 20 ins. 1924.	Girth at 20 ins. 1927.
	1st year Nov. 1924— Oct. 1925.	2nd year Nov. 1925— Oct. 1926	3rd year Nov. 1926— Oct. 1927.			
A 95	7.8	12.3	13.4	18	38	44
F 15	7.8	8.6	—	12	32	—
E 46	7.7	12.0	18.2	11	33	33
D 93	7.7	9.0	—	13	33	—
B 2	7.6	10.0	—	10	27	—
F 46	7.6	10.5	14.7	10	43	45
F 55	7.6	10.6	—	10	28	—
C 53	7.4	12.4	—	14	37	—
A 90	7.4	9.7	—	11	30	—
B 99	7.4	10.6	12.0	12	39	41
E 91	7.4	10.6	—	10	25	—
C 11	7.1	10.0	—	12	30	—
F 34	7.1	8.9	—	10	37	—
A 47	7.0	9.9	—	9	27	—
B 72	7.0	7.7	—	8	25	—
D 48	7.0	12.5	—	12	33	—
A 32	6.9	10.7	29.9	6	28	29
A 46	6.9	8.5	—	9	28	—
D 61	6.6	8.1	15.5	7	26	28
E 85	6.5	13.3	—	12	24	—
A 31	6.4	7.9	—	14	30	—
A 62	6.2	8.7	—	13	32	—
E 2	6.2	7.2	—	13	39	—
E 61	6.2	8.2	—	11	31	—

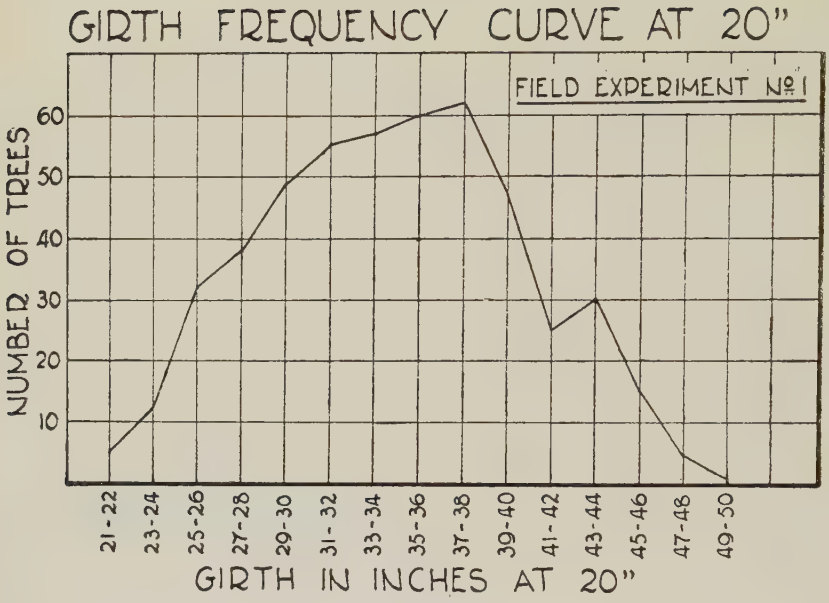
Tree Number.	Average yield per tapping in grammes, dry rubber.			Number of latex vessel rows at 20 ins. Oct. 1924.	Girth at 20 ins. 1924.	Girth at 20 ins. 1927.
	1st year Nov. 1924— Oct. 1925.	2nd year Nov. 1925— Oct. 1926.	3rd year Nov. 1926— Oct. 1927.			
B 44	6.1	9.0	—	9	26	—
C 93	6.1	10.3	—	8	34	—
E 78	6.1	8.8	—	6	36	—
E 82	6.0	6.6	—	9	24	—
E 35	5.9	9.8	—	9	30	—
F 1	5.9	8.4	—	8	29	—
E 87	5.8	6.5	—	6	24	—
D 13	5.5	6.0	—	17	47	—
D 16	5.4	11.3	—	15	40	—
F 97	5.3	6.9	25.3	11	28	30
F 18	4.7	5.9	—	7	27	—
D 82	4.0	8.2	—	13	34	—
D 79	3.7	5.0	—	8	30	—
	599 trees.	599 trees.	524 trees.			

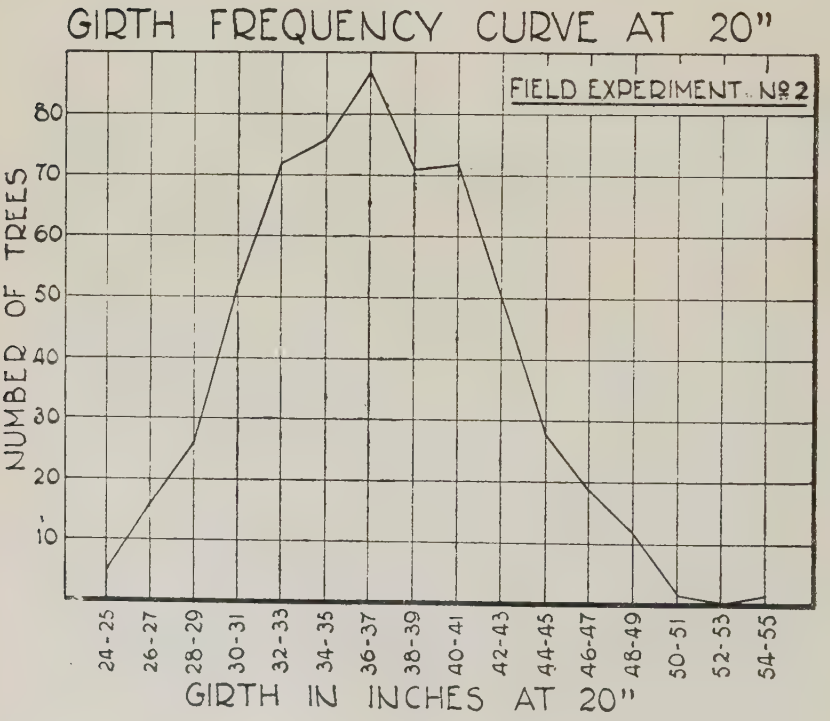
APPENDIX No. 2.

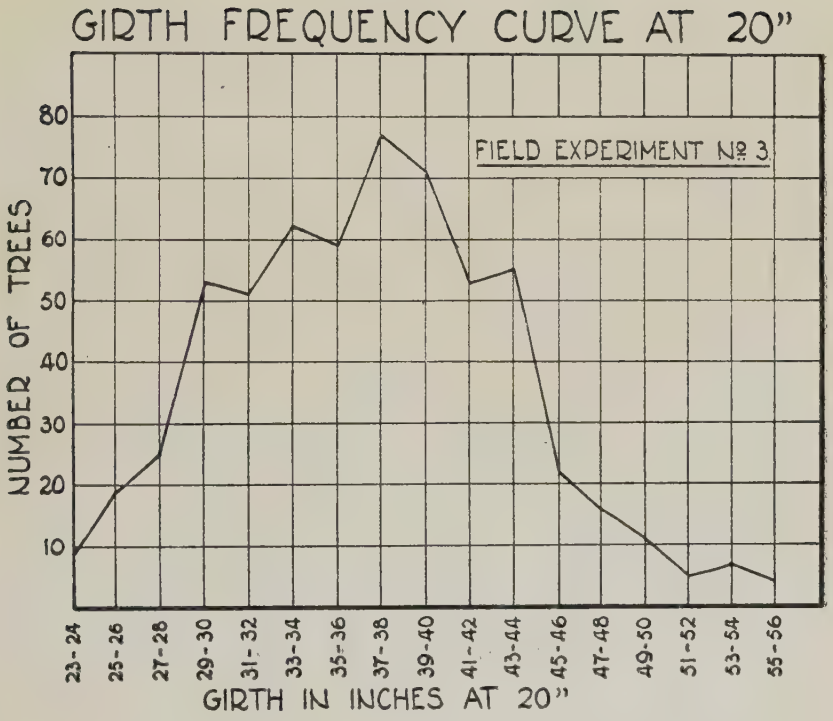
For the same character there is a notable similarity in the frequency curves for the three experiments.

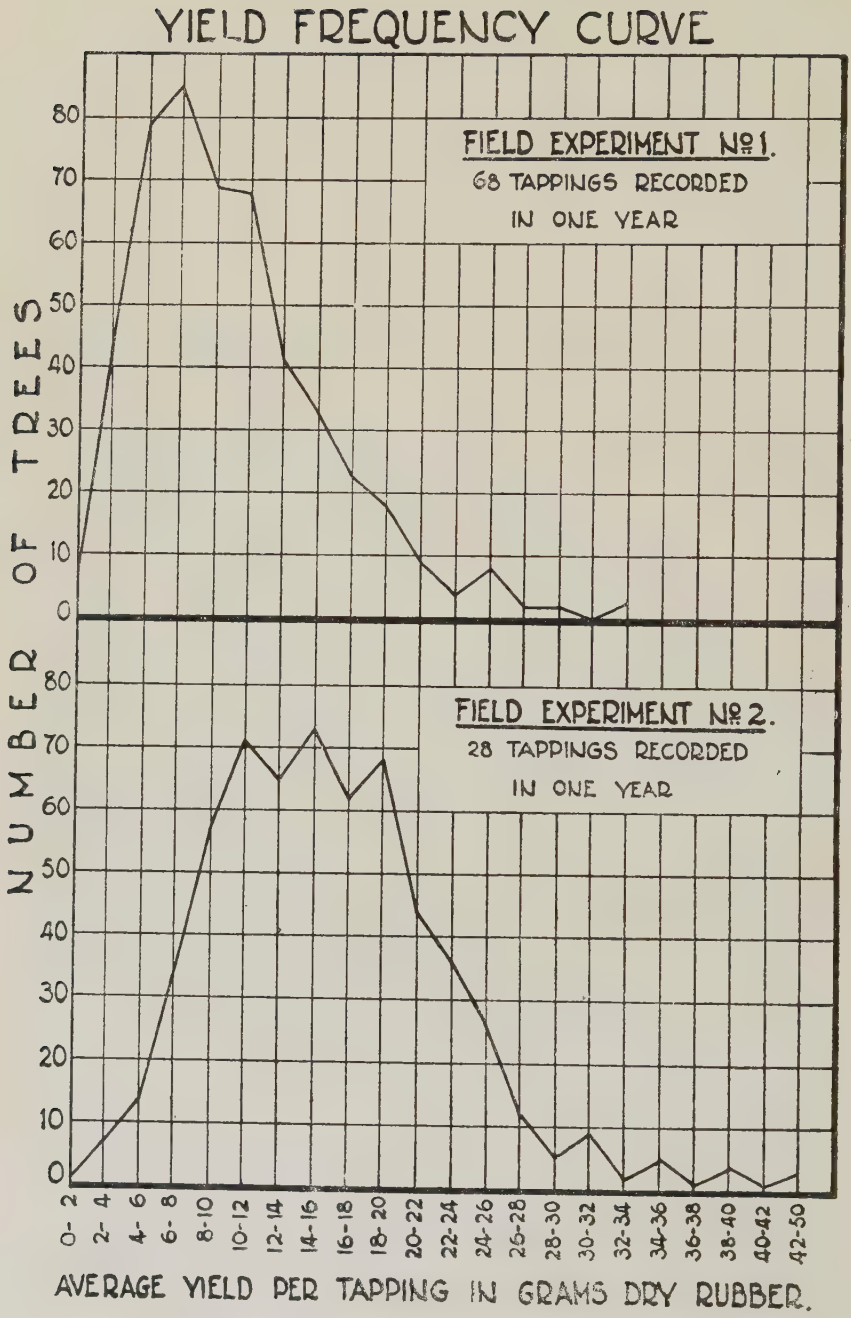
The yield frequency curves all show a similarity in the extent of skewness, indicating that the populations were similar in constitution as regards the percentage of high, medium, and low yielders. The amount of material present, from which by careful selection more productive stands might be obtained, is indicated. The yield frequency curves for the three successive years in Field Experiment No. 3 show but small differences and support the contention that, dealing with considerable numbers of individuals as group series, the relative positions of such groups are maintained for at any rate a considerable number of years or in general good yielders remain good yielders and poor ones remain poor. The experiment applies only to original bark.

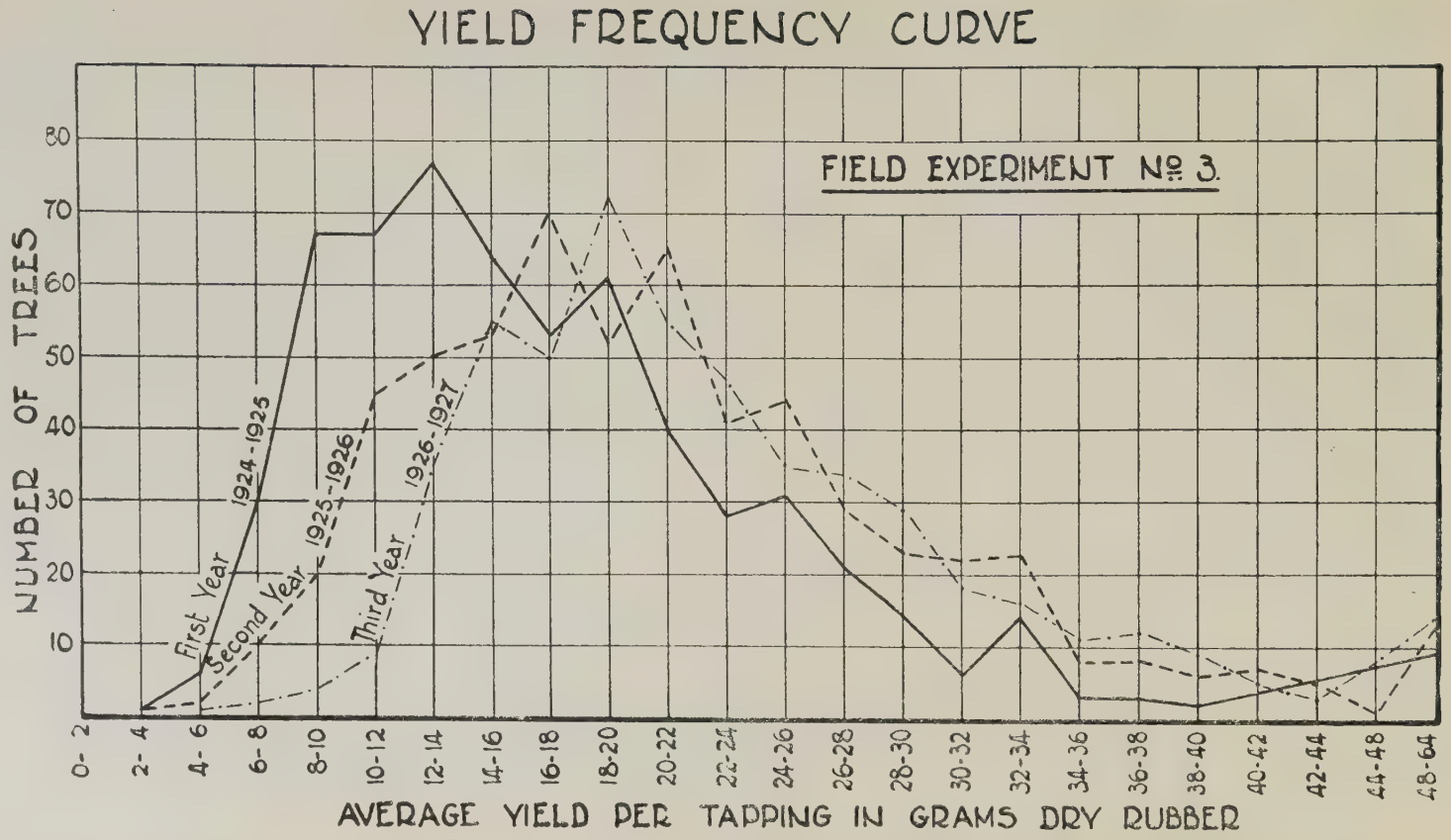

FREQUENCY CURVE FOR LATEX VESSEL ROWS AT 20"
FIELD EXPERIMENT Nº 1.
FIELD EXPERIMENT Nº 2.
FIELD EXPERIMENT Nº 3.
NUMBER OF TREES
NUMBER OF LATEX VESSEL ROWS AT 20"

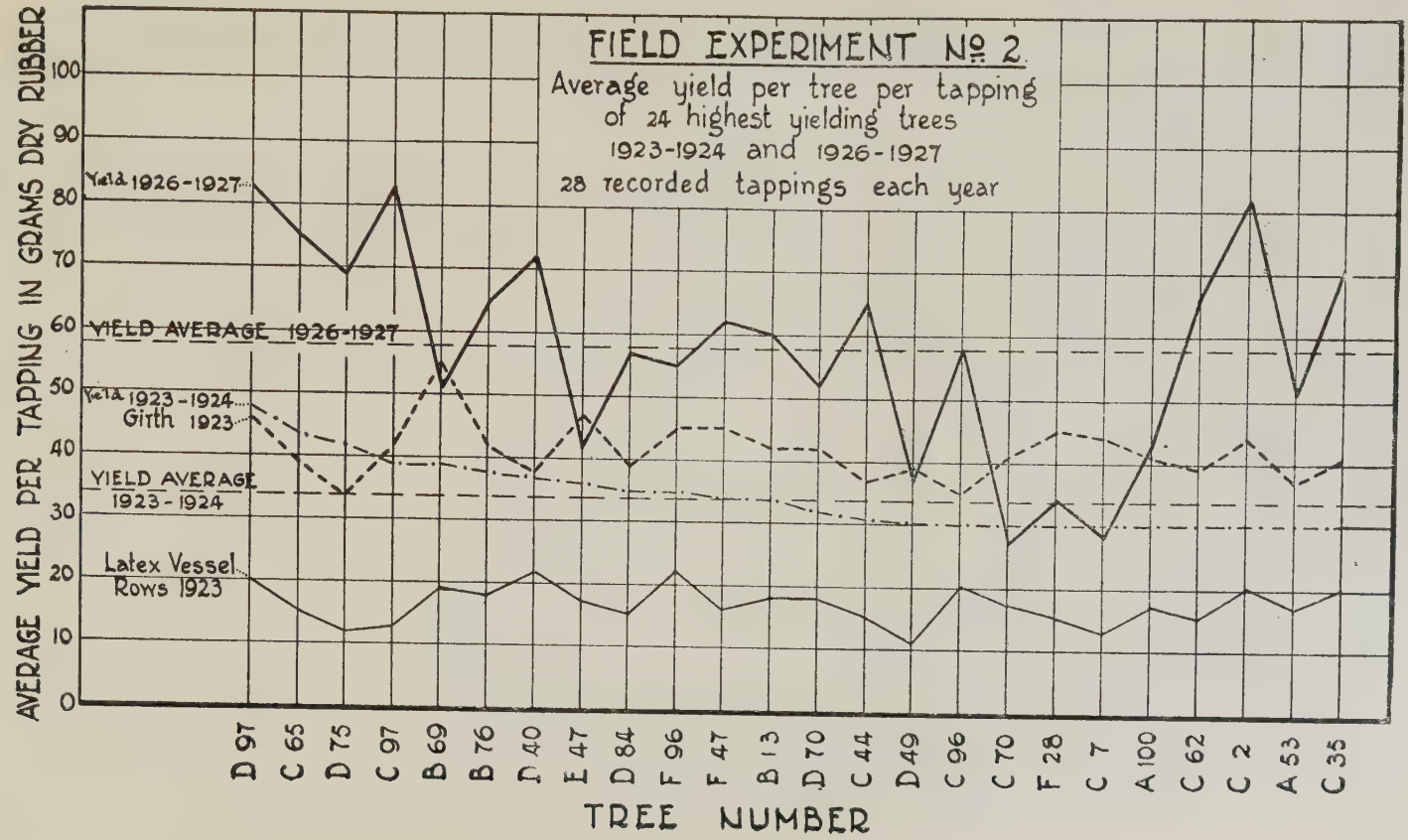

GIRTH FREQUENCY CURVE AT 20"
FIELD EXPERIMENT №1
NUMBER OF TREES
10
20
30
40
50
60
21-22
23-24
25-26
27-28
29-30
31-32
33-34
35-36
37-38
39-40
41-42
43-44
45-46
47-48
49-50
GIRTH IN INCHES AT 20"


GIRTH FREQUENCY CURVE AT 20"
FIELD EXPERIMENT №2
NUMBER OF TREES
10
20
30
40
50
60
70
80
24-25
26-27
28-29
30-31
32-33
34-35
36-37
38-39
40-41
42-43
44-45
46-47
48-49
50-51
52-53
54-55
GIRTH IN INCHES AT 20"


GIRTH FREQUENCY CURVE AT 20"
FIELD EXPERIMENT No 3
NUMBER OF TREES
80
70
60
50
40
30
20
10
23-24
25-26
27-28
29-30
31-32
33-34
35-36
37-38
39-40
41-42
43-44
45-46
47-48
49-50
51-52
53-54
55-56
GIRTH IN INCHES AT 20"


YIELD FREQUENCY CURVE
FIELD EXPERIMENT No 1.
68 TAPPINGS RECORDED
IN ONE YEAR
FIELD EXPERIMENT No 2.
28 TAPPINGS RECORDED
IN ONE YEAR
NUMBER OF TREES
0
10
20
30
40
50
60
70
80
0- 2
2- 4
4- 6
6- 8
8-10
10-12
12-14
14-16
16-18
18-20
20-22
22-24
24-26
26-28
28-30
30-32
32-34
34-36
36-38
38-40
40-42
42-50
AVERAGE YIELD PER TAPPING IN GRAMS DRY RUBBER.


YIELD FREQUENCY CURVE
FIELD EXPERIMENT No 3.
NUMBER OF TREES
80
70
60
50
40
30
20
10
First Year 1924-1925
Second Year 1925-1926
Third Year 1926-1927
0- 2
2- 4
4- 6
6- 8
8-10
10-12
12-14
14-16
16-18
18-20
20-22
22-24
24-26
26-28
28-30
30-32
32-34
34-36
36-38
38-40
40-42
42-44
44-48
48-64
AVERAGE YIELD PER TAPPING IN GRAMS DRY RUBBER


FIELD EXPERIMENT No 2.
Average yield per tree per tapping
of 24 highest yielding trees
1923-1924 and 1926-1927
28 recorded tappings each year
AVERAGE YIELD PER TAPPING IN GRAMS DRY RUBBER
Yield 1926-1927
YIELD AVERAGE 1926-1927
Yield 1923-1924
Girth 1923
YIELD AVERAGE 1923-1924
Latex Vessel Rows 1923
0
10
20
30
40
50
60
70
80
90
100
D 97
C 65
D 75
C 97
B 69
B 76
D 40
E 47
D 84
F 96
F 47
B 13
D 70
C 44
D 49
C 96
C 70
F 28
C 7
A 100
C 62
C 2
A 53
C 35
TREE NUMBER

APPENDIX No. 3.

Field Experiment No. 1.

Percentage of Dry Rubber Content of Latex.

The accompanying table shows the results of determination of dry rubber content of latex. The figures have been obtained from the total yield of latex for 68 tappings spread over 12 months against the weight of dry rubber.

A glance at the table shows that in Series A and E the dry rubber content on average is considerably lower than for Series C, D and E. The difference is probably due in large part to the fact that in October and November 1922 and again in April and May 1923, portions of these areas were subject to severe flooding for several days at a time. The number of trees yielding on average latex with a dry rubber content of less than 2½ lbs. per gallon is surprisingly large.

It should be noted that the opposite end of the table may be influenced to some extent by the amount of cut scrap, the weight of which is included in the dry rubber weights.

A number of trees of which the volume of latex could not be accurately measured, owing to rapid coagulation in the cups, are excluded from the records.

The coefficient of variability (14.6) is so high that volumetric determination of yield alone could not be relied on to select a small percentage of trees as mother trees. Final determination of yield should be by weight of dry rubber.

TABLE No. 10.

Field Experiment No. 1.

Percentage dry rubber content of latex.

Series.	16-20	20-22	22-24	24-26	26-28	28-30	30-32	32-34	34-36	36-38	No. of Trees.
A -	7	10	11	17	22	19	4	4	1	—	95
B -	—	2	2	7	18	18	17	12	8	4	88
C -	1	1	6	12	18	18	16	11	6	3	92
D -	1	—	5	10	9	25	24	16	6	1	97
E -	5	8	17	27	22	8	7	2	2	—	98
	14	21	41	73	89	88	68	45	23	8	470

Extreme variation = 22 per cent.

Coefficient of variability = 14.6 per cent.

Acknowledgments.

The three experiments were started and continued from 1922 to 1926 under the auspices of the Rubber Growers' Association. Extracts from time to time dealing with the progress of the experiments appear in the "Bulletin," the official publication of the R.G.A.

The authors take this opportunity of thanking the Directors of the Pataling Rubber Co., Ltd., the Directors of the Sungei Way Rubber Estates, the Directors of the Pilmoor Rubber Co., for facilities granted for carrying out the experiments and also to thank Mr. T. R. Harvey, Manager of Pataling Estate, Mr. W. S. Reeve-Tucker, Manager of Sungei Way Estate and Mr. W. H. Bragg, Manager of Pilmoor Estate, for help and suggestions whilst the experiments were in progress.

Coefficients found by other Investigators.

Whitby, G. S.		
Girth and yield (dry rubber)	+ .260	± .02
Rijks, A. B.		
Latex vessel rows and yield (latex)	+ . 51	
Bobilioff, W.		
Latex vessel rows and yield (dry rubber)	+ . 55	± .051
Heusser, C.		
Latex vessel rows and yield (dry rubber) 4 years old trees	+ .426	± .082
Latex vessel rows and yield (dry rubber) 5 years old trees	+ .535	± .071
Latex vessel rows and yield (dry rubber) 6 years old trees	+ .536	± .071
Girth and yield (dry rubber)	+ .326	± .067
Yield (dry rubber, 4th and 6th year)	+ .641	± .059
Gehlsen, C.A.		
Latex vessel rows and yield (Latex) 1920/1921	+ .585	± .028
Latex vessel rows and yield (Latex) 1920/1921	+ .589	± .027
Latex vessel rows and yield (Latex) 15 year old trees	+ .578	± .083
LaRue, C.D.		
Latex vessel rows and yield (dry rubber)	+ .513	± .016
Girth and yield (dry rubber)	+ .299	± .019
Latex vessel rows and girth	+ .162	± .021
Bryce and Gadd.		
Latex vessel rows and yield (dry rubber)	+ .459	± .042

Latex vessel rows and girth	+ .399	± .046
Girth and yield	+ .582	± .035
Belgrave, W.N.C.		
Girth and yield Plot A. (dry rubber)	+ . 39	± . 08
Girth and yield Plot F. (dry rubber)	+ . 55	± . 06
Taylor, R.A.		
Yield and Yield (dry rubber) 1922/23, 1923/24	+ .834	± . 06
Yield and Yield (dry rubber) 1923/24, 1924/25	+ .735	± .025
Yield and girth (dry rubber) 1923/24, 1924	+ .378	± .046
Yield and girth (dry rubber) 1924/25, 1925	+ .408	± .045
Yield and latex vessel rows 1924/25, 1925	+ .574	± .037

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(3) Bryce, G. and Gadd, C.H. (1922). Improvement in Hevea by the selection of seed bearers. Department of Agriculture, Ceylon. Bulletin No. 55.

(4) Bryce, G. and Gadd, C. H. (1924). Yield and growth in *Hevea brasiliensis*. Department of Agriculture, Ceylon. Bulletin No. 68.

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(8) Rijks, A. B. (1920). An investigation of bark and thinning out. Archief voor de Rubber-cultuur, **4,** 354—360.

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THE PROBLEM OF SOIL ANALYSIS.

BY

C. Falconer Flint.

At the present time the assistant staff of the Soils Division of the Rubber Research Institute are occupied principally in the analysis of soil samples sent in for advisory purposes. This work must be regarded as of considerable importance, for an advisory centre is an absolute necessity to the planting industry and it is clearly part of the duty of the Institute to endeavour to fill that urgent need.

The questions asked of Soils Division may generally be expressed as one of two fundamental queries. Most usually the soil is known to present difficulties, and recommendations for amelioration are required: we are asked "How can this soil, of which I am sending you a sample, be made more suitable for the growth of rubber trees or a cover crop?" Or the potentialities of the soil are not known and we are required to state them. The second question therefore is "How suitable is this soil, of which I am sending you a sample, for the growth of rubber trees or a cover crop?" What actually happens in most cases, is that we receive a letter which states the problem and requests that a soil analysis be made to solve it.

More rarely the sample is simply accompanied by a request for a soil analysis, but our mere compliance with this request would certainly be followed by a demand for an interpretation of our figures. Quite obviously it is not the figures but the soil expert's opinion that is of value: in fact the figures are only sent to inquirers to be filed as an interesting souvenir. This remark is not a cynicism but a warning; for it is highly probable that in the not-too-distant future advisory soil scientists will be employing methods of soil examination which, while they will answer questions on fertility with greater precision than the methods at present in use, will not afford any neat tables of percentages to send along with a letter of recommendation.

Faced by a table of the results of a soil analysis, the planter runs his eye down the columns and enquires "What's bogey?" or words to that effect. Unfortunately the figures are not as easy to interpret as a golf card. It is the purpose of this article to comment on their interpretation and to discuss some of the problems that arise when an attempt is made to estimate soil fertility and manurial needs by means other than those of actual field experimentation.

Soil Formation and Constitution.

There are two kinds of soils, primary and secondary. A primary soil results from the decomposition *in situ* of an igneous rock such as granite or basalt, while a secondary soil is produced when a primary soil is washed away and deposited as mud or silt on a river flood area or in an estuary. Igneous rocks have a definite crystalline structure, the whole mass being a mosaic of very variously sized crystals of quartz and numerous other minerals. Under the influence of such factors as temperature fluctuations, the age-long action of percolating water and the attentions of numerous micro-organisms, the rock disintegrates wherever it is exposed. It is interesting to reflect that the rotting of a rock, though infinitely slower than the rotting of a mass of animal or vegetable substance, is, at any rate in part, effected by very similar agencies.

When a rock rots, the minerals other than quartz break down to a substance known as clay, while the quartz crystals may remain quite unaltered and, as sand, constitute the coarser fractions of the primary soils thus formed. Clay is a substance which possesses many remarkable properties, and a word or two about modern notions of its physical structure may not be out of place. There is very sound reason to believe that each of the tiny particles of which it is composed has a hard mineral core, probably a flat flake of some mica-like substance, the rest of the particle being a thick jelly-like envelope surrounding this core. This mineral jelly or colloid (the soil contains also organic colloids of vegetable and animal origin) is of the utmost importance to the agricultural value of the soil, for it not only profoundly modifies its physical properties but is the store for the mineral food salts necessary to plant growth. Its composition and precise properties may vary within wide limits giving all sorts of different clays, but in its relation to plant nutrition one fundamental property is outstanding: this mineral colloid is able to absorb food salts from the soil water when they exceed a certain concentration and to yield them up again when the concentration falls below this value. The details of this process are highly complex and can hardly yet be handled mathematically, for the value of this equilibrium concentration alters with the innate properties of the particular clay in question, with the quantities and proportions of the salts already absorbed and with those present in solution. A given clay has a definite saturation capacity for food salts: when this is completely satisfied, the soil is slightly alkaline and when the clay is very unsaturated, i.e., contains a very small amount of absorbed plant food salts, the soil is very acid. As a generalisation one may say the degree of acidity of a soil depends

inversely on the extent to which its colloids are saturated with so-called "available" minerals.

The Micro-organic Population and its Functions.

In addition to its mineral constituents, the soil contains humus and a population, very varied as to number and species, of micro-organisms—bacteria, fungi and protozoa. These last would appear to feed on the first two groups and thus modify soil properties in quite a secondary fashion, but the bacteria and fungi exert very definite influences on plant growth, both beneficial and harmful. To explain briefly and rather crudely we may say (i) they decompose the soil minerals and make them available as food to the plant, (ii) they take nitrogen gas from the air and fix it in a form in which it may eventually become available to the plant and (iii) they decompose dead animal and vegetable matter so that its mineral content again becomes available in the soil and its carbon passes into the atmosphere as carbon dioxide gas to be again taken in by the plant leaves and built into vegetable substance. Under adverse soil conditions process (ii) may be reversed and certain minerals may be converted into a form in which they cease to be useful and may even be harmful, e.g. phosphates and sulphates may be reduced.

Thus the micro-organic population of the soil serve as the intermediaries between the stores of potential plant food and the plant. When dead vegetable or animal matter falls on to the soil, the activities of the micro-organisms cause it speedily to rot away making the minerals it contains available for the growth of other plants: not directly, of course, but by a very devious route; they are taken into the bodies of the organisms initially active in the decay and either excreted or remain in the organism until it becomes, living or dead, the prey of another tiny creature which by its own particular processes may excrete the minerals in one form or another. In the same way, should the decomposition take place under the right conditions, the nitrogen contained in the vegetable matter will become wholly or in part available as food to the living plants growing on the site. The carbon, hydrogen and oxygen contained in the decomposing tissue are finally liberated as gases and water. From the plant's point of view, this is all that could be desired, since plants themselves take their supplies of carbon, hydrogen and oxygen from the atmosphere or from rain, its condensation product.

The Importance of Humus.

But there is an intermediate stage in the decomposition of vegetable matter that is of great indirect importance to the life

of the plant. This intermediate stage is the formation of humus, a dark brown structureless substance of great chemical complexity which has a remarkable power of absorbing water and swelling tremendously by so doing. It gives to a fertile soil, if unstained by iron, its characteristic colour and imparts valuable lightening and water holding properties. In a moist cool soil, humus has a high degree of permanence, its decomposition under the action of the soil micro-organisms being very much slower than the processes that lead to its formation. It has another remarkable property—its power of holding certain mineral salts, essential alike to plant and to micro-organic growth, in a loosely absorbed condition and of taking them into that condition from the soil water in which they are dissolved. Humus can thus be considered, quite properly, as a perfectly stocked caterer for the food requirements of a whole host of soil micro-organisms, supplying them with the main necessities of life while they work to meet the requirements peculiar to themselves and in so doing accomplish much of direct or indirect use to the plant.

Nitrogen Fixation.

To take an important example, some devote their energies to the fixing of nitrogen from the air: they build it into their bodies and at their death increase the reserve of this important element available to the soil. Remark that they will only do this when the percentage of nitrogen in the humus falls below a certain value. Nitrogen is essential to the vital processes of all the micro-organisms, but the great majority, lacking the power to take this element from the air, must simply suffer a restriction of their activities should adequate supplies in the humus be lacking. Under these conditions, other foods being available in sufficient quantities, the nitrogen fixing organisms will respond to the slackening of competition by multiplying and flourishing exceedingly.

Micro-organisms and the Mineral Nutrition of Plants.

Other organisms, it would appear, obligingly sit by and feed the plant roots; and in a remarkably simple and effective fashion. For a long time it has been established to almost everyone's satisfaction that plant roots absorb their food salts only as a water solution. More recent researches on the food requirements of plants, on the quantities of water a plant will "perspire" (its only excretory system) during its lifetime and on the quantities of these food salts present in the main bulk of the soil water, make it abundantly clear that the plant root must be able to tap a solution that is very much more concentrated. There is good

evidence to believe that what actually occurs is as follows: a colony of organisms grow around a soil particle that satisfies their mineral food requirements. Lack of a particular food salt develops in the fine feeding roots of plants a latent property known as chemotropism i.e. when in water containing a feeble concentration of the desired food they will grow towards the region where that concentration is highest. Now the carbon di-oxide gas excreted by the micro-organisms will make the region immediately around the soil particle, enclosed as it is by the film of slime they excrete, distinctly acid and this degree of acidity once imparted (i.e. the buffer effect of the soil solution once overcome) the traces of organic acids also excreted by the organisms will give a very high degree of acidity in a strictly limited region. This acid water rapidly removes all the food salts absorbed by the mineral jelly surrounding the soil particle and, acting through the protective layer of jelly, dissolves further the mineral core of the particle. Some of the solution produced, of much higher concentration than the surrounding soil water, diffuses out of the colony of organisms and forms a series of concentric zones of progressively decreasing concentration to lead the chemotropic feeding root to the mass of slime surrounding the particle. Here, as close as possible to the particle, the rootlet remains, flattening itself around it and feeding on a liquid of far greater concentration than anything that could be extracted by expressing or displacing the water from the bulk of the soil.

It should be pointed out that this process whereby colonies of micro-organisms dissolve and decompose soil mineral particles is not entirely independent of the presence of the plant root. By removing certain food salts as soon as they become available, the rootlets displace an equilibrium that would otherwise be set up and permit fresh quantities of the salts to be brought into solution. Sometimes the amount of one salt that can be brought into solution depends on the concentration in the solution of another substance. In this case, supposing a particular plant to have a high requirement for both, it would get ample supplies of both: but a plant of another species which needed much of one and little of the other would allow a considerable concentration of the unwanted substance to accumulate and this would set up a condition of equilibrium and prevent further supplies of the wanted substance from dissolving. Granted certain conditions, this soil would then be fertile for the one species of plant and relatively unfertile for the other.

And let it be noted that we know regrettably little about the food requirements of the rubber tree at the various stages of its growth.

In the absence of any plant roots, the solution process is still applied very effectively to the soil mineral particles, if less rapidly. A state of equilibrium is, it is true, set up but the gradual diffusion of the concentrated solution of food salts through the film of slime upsets the balance and permits of fresh dissolution, while the concentration of the external soil water is instantaneously reduced to normal by the action of the mineral and humus jellies both of which, as has already been noticed, have the power to absorb food salts from solution.

Chemical Analysis of Soils.

How then is a suitable system of soil analysis to be arranged? What is to be determined and how? A method that has been in use for many years is to boil the soil sample for a lengthy period with strong hydrochloric acid and, after filtering, to analyse for the necessary plant food salts the resultant acid liquid under the assumption that this treatment will not only decompose the humus and mineral jellies but will also take as much from the actual mineral fragments of the soil as would ever, in the course of many years, be made available to a growing plant. This treatment certainly decomposes the jellies or colloids and it certainly attacks the mineral fragments, but over any period of time during which it would be practicable to employ it in a laboratory it does not effect anything like a complete decomposition of the minerals. Apparently, one could reasonably argue that such treatment with a strong mineral acid must be far more effective than any treatment that plant roots or micro-organisms could bring to bear on the mineral particles, but experimental evidence indicates the reverse to be the case. Experiments have been described in which soils have been subjected to prolonged extraction with strong hydrochloric acid and subsequently well washed with pure water until all traces of the acid were removed and, even then, certain plants were able to make some growth and to extract mineral salts for the purpose from the soil. Incredible though this may, at first sight, seem, a little reflection will soon demonstrate that on a basis of known facts it is not so very remarkable. A digestion with strong acid for 48 hours would be a lengthy and inconvenient business not often resorted to, while for plant growth persistent action over 3 months or 3 years is all one for the patient processes of Nature. Her reagents, applied as I have already indicated, are less powerful as regards acidity but they probably have other subtler and more vitally destructive qualities and they are certainly applied more intimately and with an immediate removal of all the products of dissolution as soon as they are formed.

Methods of ultimate analysis—that is to say, methods that completely decompose the soil particles however large or resistant

they may be—can, of course, be employed with scarcely more trouble than the strong acid extraction. But such methods are quite obviously too violent for our purpose and the figures they yield represent a potentiality removed from practical significance by ages of geological time.

We might agree on some gradual method of decomposition, nevertheless capable of achieving complete solution of the soil particles in a reasonable period of time and, by making periodical analyses during the course of the decomposition, obtain figures showing the various rates at which all the potential food salts pass into solution. Such a method would be possible, but it would be a very complicated and lengthy process to perform on even a single soil sample. Let us assume that we have such figures available for a series of soils whose respective fertilities for a particular crop we wish to predict and compare. What further information, if any, do we require?

Interpretation of Chemical Analyses.

We must first safeguard ourselves by admitting the possible existence of all sorts of unknown factors that may not be as yet suspected by Agricultural Science. Then we must know the plant's needs of each of the mineral food salts at the various stages of its growth, remembering that the absorption of a much needed salt present in adequate quantities in the soil solution may be seriously hindered if other materials are present in proportions to which the physiology of this species of plant at this stage of its growth objects: thus we need accurate information on this possibility also.

We must next inquire about the plant's accessory food requirements, i.e., whether it is necessary for healthy growth that mere traces of certain rare or unusual substances be present in the soil.

It is now of fundamental importance to consider the rate at which those decomposition processes which we have endeavoured to imitate in the laboratory will actually occur in the soil under natural conditions. For rapid decomposition of the minerals and preparation of the food supplies a healthy micro-organic population of marvellously diverse species, well balanced in numbers and in action, is required. The wrong species must be discouraged. This proper condition of the micro-organic population will be governed by the availability and proportions of the food salts present, by the humus content of the soil, by its physical structure and colloidal content, by the nature of the sub-soil, topography, local climate; in fact by everything that can affect soil temperature, drainage and aeration, not forgetting such important

matters as the nature of the vegetation carried and the extent to which it shades the soil and prevents evaporation and wash. Truly, where the factors governing soil fertility are concerned, there are "wheels within wheels". To say nothing of the now well-known fact that minute traces of rare minerals in the soil may either stimulate or inhibit a particular species of micro-organic activity to a remarkable degree.

It should be emphasised that while the existence and importance of all these factors has been demonstrated and even investigated in some detail, we are very far indeed from the position in which they can be handled mathematically for any given set of circumstances and the net effect of their interaction computed. So, from what has just been written, any attempt to predict or compare soil fertilities by laboratory work would seem a very difficult matter indeed.

In actual practice, the position is somewhat ameliorated by the fact that nature is an adept at making the best of a bad job. So while it would be impossible to arrange a series of soil samples in order of fertility on the basis of such an analysis, the figures obtained merely by the analysis of the strong acid extract of a soil will furnish certain useful information. It will give a rough idea as to what is easily available to a strongly growing plant, assuming that other conditions concerning situation, climate and subsoil are favourable, and it will indicate any gross deficiencies. If there is a gross deficiency of any important food salt, the soil has obviously not even potential fertility: and since supplies of this food must be added before any sort of fertility can be developed, it also gives an indication of manurial needs. All the finer points of the complete problem of soil fertility are, of course, ignored e.g., the fact that a substance appears in the acid extract is no guarantee that most or indeed any of it is available to the plant root, and the fact that there exists a gross deficiency of a certain food salt in the soil is no guarantee that any addition of that food in artificial fertilisers will not immediately be locked up by this particular soil in an insoluble form in which the plant can make no use of it. The existence of both types of phenomenon is an established fact. But generally, if the site and climatic conditions are favourable and the necessary mineral salts are available at all, nature will contrive to arrange at least a fair degree of fertility. Beyond that, to attempt to arrange soils in order of fertility is quite impossible.

Available Nitrogen.

A few further remarks must here be made about the nitrogen supplies of the soil, since although adequate supplies of this ele-

ment are essential for any sort of plant or micro-organic growth, mineral analysis of the soil cannot indicate whether a sufficiency would be available. Broadly speaking, nitrogen is present in the soil in three forms viz. (i) in undecomposed plant tissues and in the bodies of micro-organisms. (ii) in humus. (iii) as nitrate. It is only as nitrate that plants (other than legumes) can absorb nitrogen, but the nitrate content of a soil, though easily determined, can only be regarded as the currency of the moment, since the soil colloids, which have such valuable powers of absorbing and holding in reserve soluble plant foods, are unable to absorb nitrate which is consequently washed out very rapidly by the drainage water. An analysis of soil for total nitrogen can easily be made, but nitrogen existing in forms (i) and (ii) can only be made available to the plant by the action of a healthy micro-organic population. Further the replenishing of this nitrogen supply by fixation of nitrogen from the air, can only be effected by an active micro-organic population; which assumes a plentiful mineral food supply, and the presence of decomposing vegetable matter from either properly applied green or farmyard manure or from a previous growth of vegetation.

Biological Methods.

From the foregoing paragraph it would seem that by far the simplest and most promising methods for the laboratory study of soil fertility and manurial needs would be those involving an actual study of the health, nature and activity of the soil micro-organic population. Such methods have, of course, been proposed and enough work has been done to show that this line of attack is a very promising one. In fact, so interesting are the results of this study that the need for research along these lines is of immediate importance to any organisation or industry interested in the laboratory examination of soil samples.

It has been written, and often quoted in this connection, that the plant's opinion of the fertility of the soil is to be preferred to that of the laboratory expert. In justice it should be added that this was written at a time when soil scientists were far less alive than they are to-day to the artificiality of conventional methods of soil analysis, to the reserve needed in interpreting them and to the fundamental importance of field observations to any such work. Even at the present time, the ultimate answer to the question "How fertile is this soil in this climate for this crop?" must depend upon direct experiment or experience in the field. In most cases, however, the cost of such trial in time, money and opportunity would be so heavy as to make it a commercial impossibility, so the ideal of the scientist has become

even more emphatically that of the commercial man who consults him. They both wish to be able, one day, to learn as much about a soil by a few days' laboratory work as could be learned by years of experience in the growth of the actual crop concerned.

We are already a good step nearer that goal when we decide that if we cannot get the plant's opinion of the soil we can at least get the opinion of his tradesmen and general caterers, the micro-organisms. And there is, as is very well known, an extremely valuable way of predicting the rubber tree's opinion when clearing forest for a new planting; it consists in a critical observation of the quality of the jungle remembering that Hevea itself is a native of tropical jungles.

Mechanical Analysis.

At the present time, any sort of laboratory soil examination is or should be preceded by a mechanical analysis. When the practical man examines soil in the field he classifies it, according to the fineness of the particles which predominate, as clay, loam, sandy clay, sand, etc., His experience enables him to predict much from his observations—how the soil will respond to cultivation, whether it will drain well and be properly ventilated permitting free root growth yet at the same time affording adequate mechanical support for the crop, and storing and leading up from the water table adequate moisture. Subconsciously too, as well as weighing the conditions as regards the air and water supplies of his crop he considers their effect in keeping the soil active (that is, maintaining a healthy and useful micro-organic population) and he realises that while an excess of clay will tend to make a soil foul and stagnant it is the clay and its associated humus that hold the food and water supplies. It is, as a matter of fact, a sound generalisation that the coarser particles of a soil have no actual or potential value as a source of food salts since they are simply grains of quartz. Now this field classification of a soil is subject to the errors and variations of personal judgment, so in the laboratory a rigid mechanical classification is substituted by subjecting the soil to a violent dispersive process to disintegrate all aggregated particles and then determining what percentages of the particles fall into the different size ranges.

Some Inherent Difficulties of Laboratory Examination.

In the case of every laboratory method for soil examination there is one fundamental difficulty—that the soil is disturbed by removal from the field and preparation in the laboratory, it being, of course, impossible to replace it in its original structure. Such disturbance is bound to upset the equilibrium of the micro-organic

population and to affect seriously the permeability to air and water. All properties vary with each layer of soil from the surface downwards, yet a sample can give only an average figure, since thorough mixing is essential. The alternative would be to examine a large number of samples from progressively increasing depths—this would be impossibly long for routine determinations and so vertical division is made only into "top-soil" and "sub-soil". The necessity of mixing together a number of samples and re-sampling to get a material representative of a large area further complicates the issue.

Another difficulty, and perhaps one of the most serious yet mentioned in this connection, arises directly from the necessity of studying a soil sample removed from its normal environment. A few words only must suffice to indicate it. There is every reason to believe that the store of food salts held by the mineral and organic jellies of the soil is replenished not only by further solution of the soil particles on the spot but by absorption from the dissolved matter in the ground water which may flow along beneath the surface for a great distance or may rise from great depths. In such circumstances the value of a chemical examination would be still further reduced.

Field Observations.

We are now in a position to take a comprehensive and understanding glance at the position from the soil expert's point of view when he is asked one of the two questions previously referred to. He will first of all need all the field information available and, since it is quite impossible for him to make the observations himself in every case, he must rely on all relevant information being accurately supplied to him by the estate manager or assistant.

The soil scientist can consider only one soil type at a time—every variation constitutes a separate case. If he is unable to visit he should first be supplied with a contour sketch map of the area in question on which the extent of the soil type or types should be indicated. Since it is of first importance to get the plant's opinion of the soil, the quality of the jungle or particulars of previous crops and the life history and present condition of the existing crop should be accurately described and any unusual treatment or circumstances should be clearly emphasised. For each soil type a profile should be described in detail, i.e. the nature, sequence and dimensions of the various strata visible in a vertical section: such a profile should be as deep as possible and may be obtained from a road or stream cutting, from the wall of a hill side slip or in unfavourable cases, by digging. It should

also be clearly indicated whether great variation in the profile occurs over the area covered by the given soil type.

An elementary knowledge of geology is of great assistance here and much useful information may be obtained with relative ease by using a simple boring tool. This can be made in any workshop by screwing together sections of $\frac{3}{4}''$ iron piping with coupling collars as required, the lower section terminated by a carpenter's auger and the upper by a simple cross-bar, the soil can easily be explored down to a depth of several yards. The tool is screwed down into the soil and loosened every few turns by lifting it several inches and working it up and down in the hole. A sample of the soil in which the auger is actually engaged may be recovered from the twisted blade by simply pulling it straight up.

Soil Sampling.

After considering this information, the expert may decide that a laboratory examination of a particular horizon of the soil profile would be helpful. In this sampling, a considerable amount of care is needed if the sample is to be truly representative of the soil type to be studied: a monograph could be written on the innumerable accidents that could make the properties of the soil in any particular spot most misleading as regards the whole area. A root or a piece of wood may have rotted there, a small animal may have died there, a fragment of bone might get included, or the whole nature of the soil may have been altered by the work of ants or worms, or soil from lower strata may thus have been brought up. The tearing up of the roots of a great tree, long since rotted and disappeared, may have brought up a large amount of the subsoil. These few of the many possibilities must serve as examples of the pitfalls that are set for the unwary soil sampler. In practice they are avoided by using every care that the spot selected for sampling shall appear thoroughly normal for the area in every way and sampling at least six such spots scattered at random over the area. Thus a number of samples are taken and carefully mixed and the final samples taken from the mixture—usually after first air-drying and crushing.

A soil sample is always taken as a block: that is, a volume of the soil is isolated from the rest and everything within that volume is taken. There are several convenient ways of doing this. For surface samples a piece of stove piping, a piece of thin-walled metal tubing or a cylindrical tin is forced down vertically and then dug out or withdrawn together with the core of earth it contains. Such a core is generally 2 ins. to 3 ins. in diameter and is taken from the surface down to a depth of 9 ins. or 1 ft.

A more elaborate and convenient tool may be made by sharpening the end of a piece of suitable steel piping, splitting it down one side and fixing it to an iron rod with a wooden cross-bar. This is screwed down into the soil, drawn up, and the core forced out by working with a screw-driver or pointed iron rod through the slit.

The following method is convenient when subsoil samples are required:—dig a pit down to a little below the required depth and smooth off vertically one wall of the pit. Take an empty cigarette tin and after piercing a small hole in the bottom to permit enclosed air to escape, knock it horizontally into the soil profile at the required level until it is flush with the vertical surface and then dig it out with the enclosed soil.

The Present Position.

Unfortunately it is not possible to treat every soil type examined as a separate research investigation and to apply such of the most modern methods as would seem most appropriate: the demands on the advisory services of the Soils Division are too heavy. The length of time it takes to carry out even the simplest determinations is not generally realised by those who have had no experience of laboratory work. Efforts are being made in the Division to study the most modern methods of soil examination as regards their usefulness for local soil types, to devise others, and by careful selection and experiment finally to arrive at a routine programme that could be applied, rapidly and conveniently, to any soil sample by trained assistants, and that would at the same time permit of as accurate an estimation of relative fertility and manurial needs as the present position of Soil Science allows. The need for that sort of correlation work is keenly felt today by the advisory soil scientist. The most gratifying progress has been made by specialised research along particular lines but, if a metaphor may be permitted, the cross-country communication is still somewhat poor. This is far from being a matter for adverse criticism: it is the normal result of the rapid progress of a new science. Such work normally falls to the lot of those who undertake research work in the interests of industry and in performing this service for the rubber planting industry in this country, the Soils Division of the Rubber Research Institute has great opportunities.

In the meantime we try to satisfy the pressing present need for advisory work by the liberal and progressive interpretation of the results of field observations together with, in certain cases.

the results of a simple and conventional routine laboratory soil examination. A mechanical analysis is made to determine the percentage of sand, silt and clay and thus to permit the classification of the soil and the making of certain deductions depending on soil texture and structure. The loss of weight after strong heating is noted and a determination of the amount of organic matter and of total nitrogen is made. A portion is treated with boiling hydrochloric acid and the extract is analysed for potassium and phosporus. Thus any gross deficiences of nitrogen, potassium and phosporus are indicated, and the indication is of some value since if any such gross deficiencies exist the soil cannot be even potentially fertile. These three elements are those which temperate zone agriculturists have found to be most frequently limited in quantity and the addition of which, together with lime, has been found to be a practicable and paying proposition. In the absence of definite information, workers in the tropics must be content to follow this temperate zone practice. The need for research here is obvious, but research takes time. If and when the need is felt for other fertilisers, they will be manufactured and marketed. Until then, in our advisory capacity, we seek only soil deficiencies that can be met with the fertilisers available. On the research side, it is another matter, but one which is outside the province of this paper.

* * * * *

In conclusion the writer would end on a practical note, since he has endeavoured to write for the practical man. Although the determinations we make in the routine examination of a soil sample are definitely old fashioned, no pains have been spared to make the means by which they are carried out as modern, and consequently as rapid and as economical, as possible. Even so, such an examination of one soil sample takes 3 hours of one man's time and 5 hours of another's, to say nothing of work done in preparing and storing the samples, interpreting the results and drafting the reports. With the trained assistance at present available the capacity of the laboratory is thirty samples a month. If this work were done on a business footing, paying its own cost by the fees charged, a fee of from fifty to seventy dollars would have to be charged for each sample examined.

In the foregoing paragraphs the very obvious need for a laboratory method for determining soil fertility and manurial needs has been indicated. While emphasis has been laid on some of the difficulties of applying schemes of chemical analysis and other "dead" methods to this problem, and attention has been directed to the very promising micro-biological methods which have as their basis a study of the growth of living organisms in

the soil, it has also been pointed out that the results of even a simple chemical analysis can be of great value if liberally interpreted to supplement field observations. Such a simple analysis is, however, a relatively lengthy and costly process. These remarks will, it is hoped, afford data by which Estate Managers in Malaya may realise the nature of the services they ask for and justify themselves for the courtesy and patience they invariably show in their demands upon the advisory services of the Soils Division.

REVIEW.

The Realm of Rubber by H. H. Ghosh.

This book, published by J. B. Daymond, 76 Dhurrumtollah Street, Calcutta, in October 1928, consists of 252 pages with index, thirty illustrations, map of the world's rubber belt and chart of rubber prices from 1904 to 1926

In his preface the author states "Much of the ground covered in this work has not been traversed as yet by any other book" and again "Rubber planting is apparently the most scientific agricultural industry of the day." Although the first statement has some claims to correctness the second may be disputed, since in the reviewer's opinion the sugar cane industry in Java can probably claim this distinction.

A number of the earlier chapters of past history of the planting industry might well have been omitted without any real loss to the value of the book. In many instances the information is stated to be derived from the Encyclopaedia Britannica. An Encyclopaedia cannot be considered a valuable source of information for a book of this character.

Although it is not possible in a short review to discuss many statements, a few random criticisms will illustrate the nature of some of the information contained in the book.

Thus on page 24 it is stated "In clearing the site, all trees should be felled as closely as possible to the ground and their stumps uprooted." Most planters are aware that the stumps can only be uprooted satisfactorily if a portion of the trunk is left, in order to provide leverage for the process of uprooting.

On page 29 it is stated "Closely planted trees would be greater in number per acre than widely planted ones." Surely this is obvious without any statement to the effect.

On page 27 germinating in baskets is stated to preclude selection of seedlings. This is not the case and apart from the expense of baskets is well known to be an excellent method.

On page 30 the recommendation to plant rows of trees as disease resisting belts is not practised and is probably of little value.

On page 32 the African Oil Palm is given as a suitable catch-crop—a most unsuitable economic crop to be grown as a "catch-crop" in rubber.

Under "Pruning" on page 33 it is recommended that branches on the lower part of the trunk should be lopped off to leave a clear tapping surface. It is certainly rare to find such an occurrence.

The information in the early chapters on tapping and coagulation is out of date.

In Chapter VIII "Improvements in Preparation" no reference is made to any investigations in Malaya, which were the earliest dealing with variability of the raw product.

On page 97 it is stated that in the manufacture of sheet rubber the coagulum is passed between hot rolls which iron out the moisture. This shows an entire lack of knowledge of plantation factory practice.

On page 99 the reference to the preservation of latex with ammonia is to a paper published in 1927 whereas considerably earlier information on this subject is published in rubber literature in Malaya.

Chapter XI on rubber in India contains a lot of old information of historic value only and is also a plea for the extension of cultivation in India while Chapter XII consists of a similar plea for extension of cultivation of rubber in Burmah.

Two of the illustrations are taken from dioramas—a somewhat peculiar method of illustrating a book of this nature.

The book is primarily a compilation with very voluminous quotations and the author would appear not to have a very close acquaintance with plantation practice—hence some of the peculiar errors quoted above.

Much of the information is valuable but has not been critically selected while the author would appear to have a theoretical rather than a practical knowledge of plantation practice.

B. J. E.

A SHORT REVIEW OF THE PRESENT POSITION OF THE PLANTING OF BUDDINGS OF PROVED CLONES.

By

C. E. T. Mann.

Questions relating to the distribution of buddings in the field have received a considerable amount of attention during the past two years. To make the position more clear a résumé of the advice which has been given from time to time on this subject may prove useful.

Some six years ago Dr. Heusser, of the A. V. R. O. S. Experiment Station in Sumatra, published the results of his first test tapping experiments on budded trees (1923). The results obtained with certain clones were so promising that it was advised that the future planting material should consist of an equal mixture of buddings of the best clones and seedlings from the best available mother tree seed. At that time buddings had not been tapped for a sufficiently long period to justify planting them on a commercial scale without the precaution of mixing them with seedlings.

At the present time the position has changed considerably; the results of subsequent tapping tests over a period of six years have borne out the promise of success indicated in the earliest experiments. For certain clones, e.g. AVROS clones 49 and 50, long records are available. Of equal importance with the high yielding properties of such clones early doubts as to the future behaviour of budded trees with regard to bark renewal, resistance to disease, and liability to mechanical damage have been dispelled to a great extent.

It is important to bear in mind that the planting of seedlings mixed with buddings was advised as a precautionary measure. In the event of the buddings proving unsatisfactory in later years it was considered that this policy would allow of their removal leaving the area still fully planted with seedlings of good quality.

Since it has been proved beyond reasonable doubt that a uniformly high yielding stand of trees can be established by planting with proved clones the interplanting of seedlings is now unnecessary. Experience has shown that the yields obtained from so-called selected seedlings (the seed produced by high yielding mother trees, the male parent being unknown) are lower and much more variable than the yields obtained from buddings of good proved clones. Furthermore, the practice of mixed planting even as a precautionary measure has obvious disadvantages. In an area established on such a plan there will be a few seedlings of high yielding capacity which it will pay to

keep at the expense of a few of the buddings, but these seedling trees can only be determined by laborious individual yield tests. This would necessitate leaving all trees, except obviously diseased and weakly specimens, for at least one year of commercial tapping, i.e., until about the sixth year from planting. At this stage the thinning out of alternate trees would be a costly operation and considerable damage to the remaining trees would be unavoidable. During the whole of the period of six years the close planting (200 to 250 trees per acre) required by the system would have impaired the general growth. Since budded trees in their later years are generally a little less vigorous that non-budded trees, they would probably suffer most from the over-crowded conditions.

A further complication arises in the tapping of buddings and seedlings in the same area. The bark of a budded tree, at least in its early years, does not usually show the heavy development of outer corky tissues characteristic of the lower portions of the trunk of a seedling. This fact gave rise to the early, exaggerated reports that budded trees produced a thin bark which was hardly tappable. Actually the latex producing region of the "cortex" of a good budding is generally rather thicker than that of a good seedling. The absence of the thick outer corky layer does, however, make more careful tapping essential. To attempt to modify the tapping in a mixed area of buddings and seedlings so that both types of the tree will be correctly tapped will be extremely difficult.

These defects in the system were no doubt realised at the outset and it is not surprising therefore, as soon as sufficient data on the later performance of buddings became available, that the practice was no longer advised. The planting of buddings of good clones only, well intermingled, was advised for future developments. But still a note of caution crept into this advice. Areas were to be planted with proved clones of which tapping records were available for two or three years, and the clones were to be mixed. In large areas as many as ten clones were used in this way, sometimes in equal proportions but frequently with larger proportions of the most promising clones.

Recent work on the tapping of budded trees has shown that different clones behave very differently when tapped on a uniform tapping system. Certain clones reach their highest yield six days from the commencement of a tapping period; others reach their maximum yield at a much later period. There is, in fact, very strong evidence that, to get the best yield from a clone, tapping will have to be carried out for definite periods with definite intervals of rest and these periods will differ for different clones. Such treatment would be practically impossible in a mixed planting of proved clones.

Either, only clones of similar yield performance should be mixed in a given area or, planting should be carried out in blocks each of

a single clone if full advantage is to be taken of the individual yield characteristics of each clone. To be in a position to adopt such a policy more information is required on the behaviour of a large number of the promising clones at present available. Comparatively few clones have been tested over a sufficiently long period to justify their use in pure plantings. Many of the more recently established clones show promise of giving better results than those developed in the early days of budding. For the present therefore the desire to include promising newer clones with the best of the older established clones will generally lead to the adoption of a policy of mixed planting. During the development of the young areas thinning out will be based on the results of continued observation and recording of the original budded trees of each clone. Should the oldest buddings of a particular clone develop a serious defect in later years it will be possible to remove the young buddings of this clone from more recent plantings. The increased space made available may be utilised by the buddings of more satisfactory clones.

Applied to plantings consisting entirely of buddings of the oldest proved clones this argument loses much of its force. It seems unlikely that buddings of a high yielding clone, which has a satisfactory record over a period of ten years or more, will suddenly develop a serious defect. In such cases it may be decided to take the risk of such a possibility and, by planting sufficiently large areas each with a single clone to reap the fullest advantage from the trees when they come into bearing. It seems unnecessary to stress the practical advantages of the system from the point of view of establishment and maintenance. In the event of the failure of a clone the question to be decided appears to be whether it is better for the loss which this will entail to be evenly distributed throughout the whole area planted or whether to confine the possibility of loss to a particular portion of the area sufficiently large to allow of successful replanting in the extreme case.

Though block planting or pure planting of clones has already been adopted to a small extent, the question is raised in this article in order to indicate the trend of recent development in budding practice.

A BRIEF SUMMARY OF BUDDING PROCEDURE.

BY

C. E. T. MANN.

I. BUDDING IN THE FIELD.

OPERATIONS.

1. *Budding and shading with leaves.*—On clear hot days no time should be lost in tying on the leaf shade as soon as the binding is completed.

2. *Interval of 18 days.*—In dry weather this period may be extended to 20 days; under showery, vigorous growing conditions it may safely be reduced to 16 days.

3. *Opening.*—Remove the shade of leaves and the waxed bandage; carefully re-open the tongue of stock bark covering the bud, cut it off carefully, level with the lower edge of the bud patch. Replace the shade of leaves, fresh leaves being used where necessary.

4. *Interval of 7 days.*—

5. *Ringing.*—(See note below). On lightly scratching the bud patch both above and below the bud with the point of the budding knife the bright green colour of the "under-bark" indicates successful union of the patch and stock. A ring of bark about one inch wide is removed from the stock about 6 inches above the bud where the union has been successfully established.

6. *Interval of 7 days.*—

7. *Pruning the Stock.*—After re-examining the bud patch to ensure that death has not taken place, the stock is sawn off with a sloping cut commencing about half an inch above the bud patch and sloping towards the ground on the opposite side at an angle of about 45 degrees. When the latex has ceased flowing and the pruning cut is dry, paint with wax or a suitable wound dressing, (The wax used in preparing budding cloth is suitable).

NOTE :—The ringing operation is often omitted in field budding thereby saving the cost of an extra examination. In such cases the buddings are examined about 10 days after opening and those which appear to be successful up to this stage are pruned at once as described under 7.

Though a slightly higher percentage of losses is generally recorded after pruning where previous ringing is omitted, the economy effected in the cost of an extra examination is often sufficient to outweigh this loss.

Split bamboo shields about 18 inches long and 3 inches wide may now be placed in position about two inches away from the pruned stump and immediately opposite the 'patch'. These serve the double purpose of shading the bud patch and encouraging erect growth of the young bud shoot.

8. *Pruning side branches.*—During the first year of growth of the young budding remove all the side branches up to a height of from 6 to 8 feet from the union. To prevent the development of ugly "snags" side shoots should be removed in the "green" stage.

II. BUDDING IN THE NURSERY FOR TRANSPLANTING TO THE FIELD.

Operations.

1. *Budding.*—Shading is necessary in a wide planted nursery but in a closely planted stock nursery only the outer exposed rows of buddings need shading.

2. *Interval 14 days.*—

3. *Opening.*—Remove bandages and cut off tongues as described under Budding in the Field.

4. *Interval 10 days.*—

5. *Testing the patch and pruning the stock.*—The testing of the bud patch for successful union is carried out as described above under Field Budding. Pruning is carried out as follows:—

(*a*) If the buddings are needed for planting as soon as possible the stock is pruned off from 5 to 6 inches above the bud patch.

(*b*) If not required for immediate planting no pruning of the stock is done at this stage. The grafted bud will remain dormant as long as nothing is done to check the vigorous top growth of the stock. Buddings may be safely allowed to remain in this condition for six months.

6. *Interval (after pruning the stock) 4 to 7 days.*—

7. *Transplanting.*—The budded stocks are carefully drawn (4 to 7 days after the pruning described above). The tap root is pruned to 18 inches or two feet, the small lateral roots removed and strong laterals pruned to 3 inches. To prevent drying out immediately after transplanting, the top of the stock should be treated with melted wax, a non-injurious paint, or a suitable wound dressing. If the stumps have to be transported some distance it is advisable to dip the cut ends of the roots in the protective wax or mixture to prevent

drying out in transit. Transplanting should be carefully supervised in view of the valuable nature of budded material. After transplanting, the bamboo shields should be placed in position as in the case of buddings made in the field.

This method of transplanting is not the only one possible but it is considered to have given the best results so far.

A NOTE ON PREPARATION OF NURSERIES FOR BUDDING WORK.

By
C. E. T. Mann.

CHOICE OF SITE AND CULTIVATION.

Sheltered hollows or wide well drained ravines are generally the most suitable sites for the establishment of nurseries. In all cases the selected area should be very carefully cleared of decaying surface timber and the top layer of soil worked to a fine tilth. All surface roots and decaying timber must be removed and burnt, preferably off the selected site or near very large stumps which should be isolated from the cultivated area by isolation trenches.

The nursery beds should be laid out to run at right angles to the slope of the land and separated by sunken paths the soil from which is scattered over the bed to form a good surface tilth. It is most convenient to adopt a standard size of nursery bed to facilitate the careful labelling and recording necessary in budding work.

If seedlings are to be budded during their first year it is essential that every care be taken in the nursery work to ensure vigorous growth. One year old seedlings which only reach $\frac{1}{2}$ to $\frac{3}{4}$ inch diameter at the collar in one year are weak for satisfactory budding. The ideal to be aimed at is an even growth of vigorous seedling stocks which reach a diameter of about one inch at the collar in nine months from the date of germination of the seed.

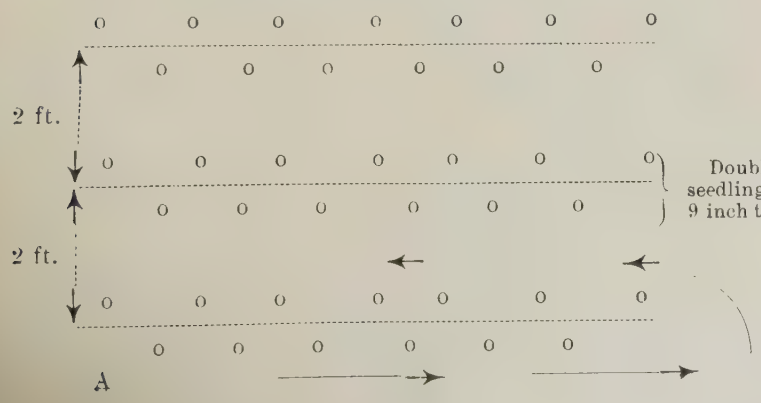
I. Nurseries for Budding Material for Transplanting.

The main points to be considered in establishing nurseries for this type of work are

(1) to allow adequate space for maximum development,

(2) to arrange that the budding coolies have sufficient room for work and to eliminate the danger of damage which will occur if the plants are over-crowded.

The following method of planting has proved satisfactory:



It can be easily arranged that each bed contains a definite number of seedling stocks, e.g. a bed 6 ft. wide and 120 ft. long will contain approximately 1,000 plants in three double rows as illustrated. Budding is commenced at A. and the budder works up one side of a row and down the opposite side as shown by the arrows. The 2 ft. wide row spacing within the bed and the boundary paths outside give ample room for comfortable work. It would be possible to bud about 50,000 plants per acre in nurseries established on this plan.

II. Multiplication Nurseries.

The whole of the prepared area is planted with germinated seeds or basket plants, the planting distance being 4 feet x 2 feet. The choice between germinated seed and basket plants will be decided by the circumstances of each particular case but, since it is imperative in this work to encourage the most vigorous and regular growth, basket planting will probably give the best results in the majority of cases.

At the age of 9 to 12 months the stocks are budded with the clones it is desired to multiply. To divide the area into individual blocks one or two boundary rows of plants may be removed as soon as the budding of a clone is completed. The block thus demarcated should be further defined by boundary posts, given a permanent and conspicuous label and its position carefully drawn on a field plan of the nursery area.

For the first year of development all plants are allowed to produce a crop of budwood; should they become obviously over-crowded, alternate plants may be removed in the second year. The spacing of 4 ft. x 2 ft. allows for about 5,000 multiplication plants per acre. Each multiplication stump should produce, given reasonable growth, at least 30 usable buds (or from 4 to 6 ft. of budwood) in one year from the date of budding. One acre therefore should give 150,000 buds or, allowing for normal losses, sufficient material to provide for 100 buddings per acre on a 1,000 acre block one year after the budding of the nursery or two years after the original planting from seed.

A multiplication nursery may be established with transplanted budded stumps of the desired clones and a saving of one year is thereby effected. A good budded stump successfully transplanted in a multiplication nursery should produce at least 20 good buds within one year.

CARE OF MULTIPLICATION NURSERIES.

By

C. E. T. Mann.

Since it is the main object of multiplication work to produce as quickly as possible healthy, vigorous and straight growing shoots suitable for use as budwood, every care should be taken of the young buddings in the early stages.

It is characteristic of many of the best known proved clones (e.g. Clone A.V.R.O.S. 152 and Clone P.B. 23) that they show a marked tendency to send out side shoots very early in their development. Should these lateral branches be allowed to develop they tend to reduce the vigour of the terminal growth so that a comparatively short main stem is developed with thin lateral branches which are useless as budwood.

1. All lateral shoots therefore should be removed in the young green stage, when they are quite soft: this can be done by merely pinching them out, a knife is not necessary. It is a mistake to allow them to develop so far that they have to be actually cut out but it is realised that during periods of rapid growth it may be difficult to catch every side shoot in its infancy.

2. To ensure healthy conditions at the union the dead "snag" of the original stock should be carefully sawn off at an angle of about 45°, the cut sloping from the upper edge of the union towards the ground on the opposite side. To prevent decay and penetration of ants or disease, the cut should be painted either with hot wax or a good preservative. This should be done as soon as the lower eighteen inches to two feet of the bud shoot has developed "brown" bark.

3. The general cultivation of the nursery must receive every attention. No weeds or cover plants should be allowed and, to keep a good tilth, the surface of the soil should be frequently broken by light forking. Where necessary low bunds and shallow trenches should be made to check soil wash and the soil collected in the trenches periodically cleaned out and scattered over the beds.

4. Manuring to encourage vigorous growth is advisable. Light dressings of cattle manure at three-monthly intervals, lightly worked into the surface soil, give satisfactory effects. Applications of a nitrogenous fertiliser, such as Nitrate of Soda, or of a mixed complete fertiliser, such as Nitrophoska, also stimulate vigorous growth. The rates of application will differ under different conditions and for advice on this point it is advisable to communicate with the Soils Division, Rubber Research Institute.

5. Incidence of leaf diseases should be carefully watched, the chief being Mites and Helminthosporium and, since damage to the foliage reacts adversely on the growth of the plants, spraying or dusting to check these troubles is worth while. The Pathological Division of the Rubber Research Institute should be communicated with in connection with this side of the work.

CUTTING AND PACKING OF BUDWOOD.

Whether budwood is being cut for use on the estate or for sale it should be remembered that it is generally uneconomical to cut budwood from multiplication plants which do not show at least four feet mature brown wood above the point of union.

Though half-mature, green wood can be used successfully the risks of bruising which attend the cutting, preparation for packing, packing and transport influence adversely the degree of success obtained with such material. The precaution of waxing the cut ends of green wood is not effective over a long period of transit for the bulk of the evaporation takes place through the thin green bark which is not as yet protected by a well developed cork layer. Further loss also occurs through the thick, severed bases of the leaves for green wood at the time of cutting is usually well furnished with healthy foliage and each leaf is often carefully cut off leaving exposed the severed ends of the big veins which conduct water from the stem to the leaf.

Generally one may assume that a budding which has made from 9 to 10 feet of growth should give two yards of good, usable budwood. There will be about two or three feet of very immature wood at the top which must be discarded.

This height is generally attained by many of the plants in a well tended nursery in about 10 months.

Such material can be cut immediately and the less vigorous plants will benefit by the increased space made available.

Cutting.

1. From four days to one week before it is desired to cut budwood from the best grown plants (the number required having been estimated) all leaf blades are removed to a point about three feet below the terminal bud. The leaf stalks are *not* removed, the leaflets are merely twisted or slashed off.

After a few days it will be found that the leaf stalks have turned yellow and fall off at a gentle tap leaving a normal leaf scar which is actually healed over with a thin layer of cork. This leaf pruning should not be carried out too soon before cutting the budwood, otherwise it will be found that many of the buds begin to grow out and are thus rendered useless from the point of view of budding.

2. The previously prepared plants are sawn off about six inches above the union. Care should be taken to make the cut at a point below which there are at least three dormant buds so that further growth of the scion is assured. (The cut should be treated later with a suitable wound dressing).

Budwood needed the same day should be cut in the early morning. For transit overnight, cut in the late afternoon. Do not cut in the heat of the day since at this time the plant contains a minimum of water and the budwood will dry out rapidly in the interval between cutting and packing.

3. No time should be lost between cutting the plants, sawing them into the required lengths of 1 yard (or 1 metre) each and conveying the bud sticks to the packing shed which should be adjacent to the nursery. The lengths of budwood are conveniently conveyed in trays, the sticks resting on clean damp sacking and covered with two or three thicknesses of the same material.

Packing for Transit.

Since the risks of damage and exposure may be just as great on a short journey by rail as by one taking several days, no distinction will be made between short and long distance packing. The packing methods should be approximately the same but the material packed may be different. For short journeys, half mature wood may be safely packed. For a journey occupying several days only mature brown wood should be used.

1. Immediately after cutting, the cut ends of the bud-sticks are dipped in melted wax to a depth of about one inch. Twisting the stick during immersion ensures an even spread and good adhesion of the wax. (It is a good plan where several clones are being dealt with to use coloured paraffin waxes free from any trace of kerosene for this purpose, reserving one colour for each clone) If the budwood has been well grown no further waxing should be necessary but where side shoots have to be removed these should be cut as close as possible to the main stem and each cut carefully waxed.

2. The essential points to be observed in packing are:—

(*a*) Each stick must be separated from every other stick so that there shall be no chafing or bruising when the package is shaken.

(*b*) To maintain this condition packing material must be used and pressed firmly between the sticks.

(*c*) The packing material must be inert (not heating when damp) and capable of retaining moisture so that the budwood does not dry out.

Packing materials which have been successfully used are:—

(1) Well pounded fresh coconut fibre.
(2) Fine sawdust previously sterilised.
(3) Finely powdered and sieved wood charcoal.

(1) In the case of coconut fibre each stick is wound around with long damp fibre and the wrapped sticks pressed close together in the packing crate. A layer of shorter fibre is first placed on the bottom of the box which may be lined with banana leaf bases. Packing is completed with a good thick layer of damp fibre which should be well pressed down at the two ends of the crate. The nailing down of the cover completes the pack, making it perfectly firm.

(2) & (3) With sawdust or charcoal it is usually necessary to line the case with slightly damp sack cloth. A thick layer of the sawdust or charcoal which should be made damp before use is spread evenly on the bottom of the box and a suitable number of bud-sticks are pressed gently into it. A second layer of packing material is spread over the sticks and pressed down firmly. This is repeated until the last layer of budwood comes to within an inch of the top. The remaining space is filled with the damp (sterilised) sawdust or soft damp charcoal, the sack lining is pulled over and the cover nailed down.

Soft wood crates 3 feet 6 inches long for 1 yard lengths of budwood or 4 feet long for 1 metre lengths of budwood 1 foot 6 inches wide and 1 foot deep will hold about 50 yards (or metres) of normal budwood well packed.

Coconut fibre packing requires slightly larger cases, the length may be the same but the width and depth dimensions should be increased to 2 feet and 1 foot 6 inches respectively.

A NOTE ON CLONE TRIAL PLOTS.

By

C. E. T. Mann.

It has been found in previous experimental work on the establishment of new clones that only a comparatively small number of selected high yielding mother trees give high yielding clones. Different workers have obtained varying results in this respect but for the present one may assume that the percentage figure is not greater than 10 per cent.

The reasons for this are numerous; some of them are clear and others are still obscure. The capacity of a tree to produce latex is influenced by three sets of factors. This division is simple but somewhat artificial for all the factors are closely inter-related.

(1) External factors—soil, climate, altitude, the proximity of other trees, disease, tapping system, and time of tapping.

(2) Internal factors—the development of the latex vessel system, its extent and special characters (morphology).

(3) Inherent ability of the tree to produce latex (physiology).

1. It is quite possible to visualise a tree possessing a moderately well developed latex vessel system and a fair capacity to produce latex. Such a tree growing under very favourable conditions may be a steady high yielder, but buddings from this tree, planted under different conditions less favourable than those under which the mother tree was growing, may prove to be either medium or even poor yielders. This point should be always borne in mind in selecting mother trees for trial. Any tree, no matter how promising its yield may be, which appears to enjoy special advantages of position should be regarded with suspicion.

2. Internal characters which are measurable such as the number of latex vessel rows and their distribution and the size of the latex vessels are all contributory factors influencing yield but even a tree possessing an exceptionally well developed latex system may be a moderate or poor yielder. A study of form alone (morphology), though it contributes some evidence worthy of consideration in the final selection of a mother tree, is quite inadequate in itself.

3. No matter how good a tree may appear from its yield record and a study of its latex vessel system, if the capacity to fill the latex system is not inherent but induced by special conditions, then it is very probable that the tree will not give high yielding buddings. This peculiar property of Hevea still awaits a full explanation and only very careful chemical and physiological study will aid in its elucidation.

From these considerations it is clear that extensive budding from new mother trees would be uneconomical; the risk of obtaining 90 per cent. of trees which are no better, and may be poorer, than ordinary plants grown from seed is too great. The aim should be to establish only a sufficient number of buddings from each selected mother tree to give a reliable test when the tapping stage is reached. For this purpose from 20 to 30 buddings from each mother tree should be established and, for the purpose of direct comparison when the tapping stage is reached, buddings of a good proved clone of long standing should be interplanted with the unproved material.

A plan similar to that detailed below is suggested.

Clone Trial Plot.

Planting distance 12 ft. × 24 ft. or such as to allow about 150 trees per acre.

(1) Alternate trees to be budded with buds from the selected mother trees:—Unproved buddings 75 per acre.

(2) The remaining trees to be budded with buds from a good proved clone:—Proved buddings 75 per acre.

A stand of 150 trees per acre would allow for two years' tapping without serious thinning out by which time it could be decided whether to retain the "standard proved clone" trees or the new buddings. Should all the latter prove to be inferior to those of the proved clone their complete removal will still leave the area almost fully planted with about 70 trees per acre of a high yielding clone.

A plot of 10 acres established on these lines would provide for the trial of about 30 promising mother trees.

For our own clone trial work on the Sungei Buloh Experiment Station we have chosen as our control, or standard clone, Avros Clone 50. This choice was not made on account of its exceptional yielding capacity for there are other clones which are better in this respect; but this clone possesses a long and reliable record and so far has shown no serious defects.

FACTORY ECONOMICS

IN THE

PREPARATION OF RAW RUBBER.

By

B. J. Eaton.

There are many aspects of more absorbing and more fascinating interest from the point of view of both the lecturer and his audience than the one which I have selected as my subject for this conference. It is not a subject on which the lecturer can indulge in any fancy flights of oratory. Scientific research workers are, however, frequently accused of not being practical, or of ignoring the problems of cost. While this may be true to a certain extent of those scientific workers who are engaged in what for the sake of convenience may be described as pure research, it is not true of those of us who have to apply our research to commercial or practical problems.

Secondly the chemist who is engaged on applied research in connection with any branch of industry, whether in respect of the manufacture of some chemical product, in the examination and testing of the purity of material or, as in the case of our own industry, in the application of chemistry to a specific branch of agriculture, should and must always consider the problem of cost and profit.

The application of chemistry, as indeed of any other branch of science to a specific industry or product, is concerned first in the production of new and possibly more economic methods of preparation and secondly in the reduction of cost of preparation of a product already being prepared, or the improvement of the existing product whereby it may fetch a higher market price.

Other branches of science, such as botany and soil chemistry and physics, are concerned in the case of the plantation rubber industry in growing two "blades" of rubber trees where one grew before, that is, to increase the output of crop per unit area. I do not think that the scientific officers connected with the rubber industry in Malaya or in the Far East generally, the Netherlands East Indies, and Ceylon, have ignored the primary consideration of costs. One of the most practical books in connection with factory practice on estates is Morgan's book on the Preparation of Rubber. Whitby also in Malaya first drew attention to the problem of variation in yield of individual trees and paved the way for the consideration of the principal problem which concerns the industry at the present time—viz. improvement of yield by vegetative or other methods of selection. Grantham has shown the value of manuring in improving yields in specific instances.

The function of our own Institute—the Rubber Research Institute, is, in my opinion, twofold. It must concern itself with fundamental problems of research in connection with methods for the improvement of yield, possible new methods of preparation of the raw product and fundamental research on the nature and cause of pathological diseases of the tree.

Secondly it must concern itself with the amelioration and improvement of existing methods of cultivation and preparation, pending the possible discovery of any valuable new methods.

It is essentially an Institute for applied research, although this does not preclude pure research problems.

Generally perhaps, the research worker is more keen on research for its own sake than on its application, and may tend to lose sight of what must be the principal aim, if a sordid one, of the industry itself, the earning of profits for the shareholder. The chief difficulty of the research worker, especially in some directions such as the improvement of yields by selection in the case of a perennial like the rubber tree, is that the results may not be obtained in a lifetime and his scientific credit may only be gained after he has passed away. Secondly the benefits may accrue only for posterity and not the present generation of planters or shareholders. Naturally the cry is for immediate results and if these are not obtained the blame is too often laid on the worker.

I must not digress further in these directions, but come to a consideration of the immediate subject of our lecture.

The problems of factory economics are not chemical—in fact many of them are being solved on estates by keen and efficient managers. On other estates, it is not possible to make the necessary changes which will effect economies, on account of lack of funds for effecting alterations or conservatism on the part of the Directors.

They are all problems of common sense and if they concern any particular branch of the industry it is primarily the engineering side.

I venture to state, however, that engineering problems have not been dealt with very scientifically by engineers generally in connection with estate factory practice.

The importance attached to factory control on estates in Malaya varies considerably and may be said generally to be small.

The variation in appearance and attractiveness especially in the case of smoked sheet rubber, from different estates in Malaya is great. I speak from my own experience in visits paid to estates and from samples received. As we all know, rubber is bought and sold chiefly on appearance. While we are aware that appearance does not necessarily indicate the intrinsic quality for commercial application, in the absence of other criteria of quality it does indicate care in preparation and such care is likely to result in intrinsic high quality.

A sample of good appearance is therefore likely to fetch a higher market price or a more ready sale if the market is glutted.

SHEET RUBBER.

I propose to deal first with the question of sheet manufacture, since this type of rubber is undoubtedly more difficult to prepare in large quantities of a uniform appearance than is thin pale crepe.

Machinery.—The greatest change which has taken place in factory procedure during recent years in connection with sheet manufacture is the reversion to the early days of the industry, when only small crops were available, in the use of light machinery. In the early days the ordinary hand mangle or roller was used for rolling coagulum. With the advent of large crops, heavy machinery was introduced, which was necessitated in the case of crepe manufacture and appears to have been adopted also for sheet manufacture.

It is now realised, however, that heavy machinery with the consequent use of a large and expensive prime mover is quite unnecessary for the manufacture of sheet and most estates have now reverted to the use of light power driven machines.

A light battery of three sheeting machines with a marking machine driven by a 2½ H.P. prime mover is capable of dealing with a crop of about 650 lbs. of dry rubber per hour, say 2,500 lbs. per 4 hours, i.e., 75,000 lbs. per month, or 900,000 lbs. per annum (the crop from 2000 acres). (Note:—A 5 H.P. Oil Engine although costing rather more, is more economical to run than a smaller power petrol engine). This, however, can only be effected at maximum efficiency and under certain conditions.

It is remarkable that no detailed attention has been paid until recently to the question of the relationship between width of pans or depth of coagulating tanks, width of sheeting machine rolls and size of cases.

This problem must, I think, be considered backwards, i.e., we must consider that the present size of case 19 inches x 19 inches x 21 inches is the standard size, since it may be difficult for the rubber producer to persuade the case manufacturer to alter the size of case.

This means that a sheet at least 18 inches wide could be made. I think you will agree with me if I state that most sheet now made on estates is not much more than half this width.

A wide coagulum can be machined practically as rapidly as a narrow coagulum so that considerable economy of labour, machinery and fuel is effected by increasing the width. In some cases this means alteration or substitution of machines. On many estates the rolls of sheeting machines are only 15 inches wide, on others 18 inches. The 2.0 B Robinson light battery has rolls of 20 inch width.

In order to make a sheet 18 inches wide, which can be done, the rolls of the machines should be 24 inches, and I recommend in any factory installation of sheeting batteries that machines having rolls of this width should be installed. I presume there is no disadvantage from an engineering point of view.

Coagulating Tanks.—The next problem is the question of coagulating tanks. Until recently most tanks were about 11 inches deep, and were filled to a depth of about 9 or 10 inches with latex.

Tanks of 15 inches depth are now available, these are of just sufficient depth for 14 inches of latex, which with a dry rubber content of 1½ lbs. per gallon, and a distance between the partitions of 1½ inches, will produce a sheet of 18 inches width, when the coagulum is rolled the day after coagulation.

An extra inch in depth, i.e., 16 inches, would probably be more convenient for stirring purposes. When practicable, the Dutch procedure of coagulating latex diluted to a dry rubber content of 2 lbs. per gallon or 20 per cent., and machining on the day of coagulation, is to be recommended. A sheet of more uniform quality is obtained by this procedure.

The next problem to consider is the distance between the partitions in the tanks. I am of opinion, from experimental work on this problem, that 2 inch spacing is preferable to 1½ inch spacing, especially if the coagulum is rolled on the day of coagulation.

This means a cheaper tank in which less aluminium is used, and less handling of coagulum. The coagulation of a latex of higher dry rubber content also effects economy in the tank capacity required, while the deeper tank also reduces the floor space occupied by the tanks.

We should also consider the most suitable width of tanks, so that the sheets can be cut into an exact number of lengths to fit the cases.

If rubber were baled instead of being packed in boxes, it would not be necessary to consider the size of cases to the same extent and we should only be limited by the width of the wet rolled coagulum which could be handled satisfactorily by the labourer, and by general considerations on the maximum width, length and weight of the bales.

It may, I think, be assumed that the present weight of a case of smoked sheet—224 lbs. i.e., 10 cases to the ton, is a suitable maximum for handling purposes and that the width of case (about 19 inches) is also suitable. For handling purposes, a longer and flatter (i.e. less deep) bale might be more convenient.

In order to illustrate the economies which may be effected by attention to details such as I have mentioned, I have figures from estates showing variation in output from 250 to 650 lbs. of dry rubber per hour, depending chiefly on the width of coagulum.

Smoke-Drying.—The next problem concerns the process of smoke-drying of sheet rubber and the consumption of fuel. The amount of wood fuel used for drying and smoking sheet rubber also varies considerably on different estates—this applies to Malaya, Ceylon and the Netherlands East Indies.

Figures for Malaya show variations of from 1 lb. to 10 lbs. of wood per lb. of dry rubber.

Figures for the Netherlands East Indies (55 estates) show variations of from 1½ lbs. to 9 lbs. of wood per lb. of dry rubber. (Note:—The lowest figure is for the Zimmermann process of drying and smoking. The general average is 1 to 3 lbs. of wood per lb. of dry rubber.

These show a considerable wastage of fuel in some cases, probably due to inefficient smoke-houses and too rapid and complete combustion of the wood.

CREPE RUBBER.

I have not so far concerned myself with any investigation of the efficiency of the machinery used on any particular estates in regard to crepeing machinery. The following observations however made by myself and others may be of interest and value.

Prime Mover.—In large crepeing factories the use of electrical power, when this is cheap, has many advantages, since lighting and fans for drying rooms can be installed.

The power consumed by the large crepeing machines is about 4—5 H.P. except for the first macerator which may absorb from 5 to 7 H.P. The power consumption can be easily measured if electrical power is used—a fluctuation of 30 per cent. in the load often occurs.

Crepeing Machines.—According to Blommendaal (A.V.R.O.S. Experiment Station, Sumatra), a battery of eight machines driven by a motor is more suitable than a battery of six machines—this battery should consist of one macerator, one medium crepeing machine, one hair grooved roller machine and four smooth roller machines. Such a battery will show less variation in total power demand at any one time.

The rolls of crepeing machines are usually 18 inches long and 12 inches in diameter. For the manufacture of sole crepe, however, some estates have installed rolls 26 inches long. Blommendaal states that on one estate in Sumatra, rolls 26 inches long and 14 inches in diameter have given much better results. During a visit to Java I observed the modern tendency to use wider rolls and to prepare a wider thin crepe. On some crepeing machines, the rolls are made up of fine grain cast iron and on others from chilled cast iron.

As a rule cast iron rollers rust and wear out more rapidly due to the action of acid serum. The writer has observed very excessive corrosion due to the machining of coagulum from deteriorated preserved (ammoniated) latex which was coagulated with an excess of acid.

The chief advantage of cast iron rollers is their better grip of the rubber, thus lessening the amount of "slip." This is particularly important in the case of the finishing smooth roll machines. The ideal material for rolls should have high resistance to wear, a high coefficient of friction against the wet coagulum, resistance to rusting and action of acids.

Grooving of Rolls.—The fact that so many types, forms and pattern of grooving exist in rolls for macerating and crepeing indicates that this problem still requires study.

The types and patterns may be classified as V, U, square, or rectangular, with horizontal, spiral and vertical diamond pattern.

The problem is chiefly one of grip in order to lessen "slip" and thus increase output.

According to Blommendaal, experience has shown that the horizontal diamond pattern has advantages over the vertical diamond pattern.

Experiments are required to determine the angle at which optimum friction occurs.

Gear Ratio.—Owing to the elasticity of rubber, it is not possible to reduce a mass of coagulum beyond a certain thickness by pressure only and as the sheet of rubber becomes thinner it becomes more difficult to reduce its thickness.

A smaller gear ratio can, therefore, be used in macerating machines than in the medium crepeing or finishing machines.

According to Blommendaal a gear ratio of 1 : 1.2 or 1 : 1.5 is desirable for macerators and this should increase towards the finishing or smooth roller machines to a ratio of 1 : 1.9. This is usually adopted in the manufacture of fine crepe for the preparation of sole crepe.

Speed of Rolls.—The speed of rolls should be as high as possible to obtain maximum output. The speed, however, is limited by the capacity of the operator and the attention required which is greater on the finishing machines.

According to Blommendaal when the teeth ratio is increased from 1 : 1.2 to 1 : 1.5 the back rolls can be allowed to rotate at 30 revolutions per minute and when it increases from 1 : 1.5 to 1 : 1.9 the speed can be allowed to attain 38—40 revolutions per minute, increasing the horse power proportionately.

A study of the problem has also been made by O'Brien, Chemist to the Rubber Research Scheme Ceylon, and the following remarks

will therefore apply chiefly to results obtained in Ceylon which, I have no doubt, can also be applied to Malayan practice.

I propose only to give a summary of the results obtained, without entering into any details of the experiments or observations. Ceylon practice in the manufacture of crepe differs considerably from Malayan practice, since the final product marketed by Malayan estates is a thin pale crepe and by most Ceylon estates the final product is a blanket crepe made from an artificially dried rough lacy crepe.

Figures for roller output are only comparable if the thickness and width of the crepe produced is known. The thickness is determined best by measuring the weight of a given area of crepe.

The output of a roller is approximately proportional to the thickness and width of the crepe.

Maceration.—In the case of horizontal grooved rollers used for maceration, a considerable amount of "slip" occurs. The actual efficiency of horizontally grooved rolls, according to O'Brien, is only 50 per cent., i.e. theoretically, if no slip occurred, the output should be double that obtained in practice.

The output is not influenced by the hardness of the coagulum, within the ordinary limits.

Soft coagulum is, however, recommended in order to minimise power consumption and wear and tear. For this reason, it is generally recommended in Malaya to dilute latex to not more than 2 lbs. of dry rubber per gallon for the manufacture of crepe. (It is of interest to note however that I have recently visited an estate, producing sole crepe, where, on account of the bad peaty water, pure latex containing $3\frac{1}{2}$ to 4 lbs. of dry rubber per gallon is coagulated). A large gear ratio is desirable for breaking down the coagulum and a smaller gear ratio for completion of maceration. A speed of 20-22 revs. per minute is considered suitable for macerating rolls since the operator cannot feed the machine satisfactorily at higher speeds; although the efficiency appears to be independent of speed. The output of a smooth roller is not influenced by the thickness of the coagulum fed into the machine.

In order to secure maximum output from a grooved roller the coagulum should be macerated at the greatest thickness which can be fed to the smooth roller without tearing.

Smooth Rollers.—Slip is the most important factor in smooth rolling as the efficiency of such machines varies from 20 to 33 per cent. The efficiency is independent of the speed within ordinary limits, although a speed of 25 revs. per minute is recommended.

The output from a smooth roller geared 17: 30, (1: 1.8), i.e. high differential speed, is slightly higher than from a roller geared 16: 20—(1: 1.5) the gain in output is approximately proportional to the increased width of crepe from the former.

Loss of output is often due to failure to utilise the full effective width of the rolls.

The efficiency of the smooth roller is considered to depend chiefly on the texture of the surface of the roller—a coarse grained texture grips the coagulum and lessens "slip."

Massive construction of crepeing machinery is essential on account of heavy service. Sloping rolls with the front roll lower than the back gives the operator better control.

The use of roller bearings is being developed and is to be recommended, provided the housings are dirt and water proof.

Dr. Riebl of the Proefstation voor Rubber at Buitenzorg has also carried out an investigation of this problem. He also points out the uneconomic procedure of using a separate motor for each machine. A large motor to drive a battery is more economical in power consumption, with a subsidiary motor in case of breakdown.

Mr. Frank Garner, General Manager of Joseph Robinson & Co. the well known makers of rubber machinery for estate factories, who has made a tour of the rubber areas in the East has also contributed a useful summary of his observations.

He states *inter alia* "It may be thought that the plant required, which is elementary from a mechanical point of view, does not call for anything but cheap and rough machinery, but this is anything but the case, since the service, especially of crepe machinery is arduous and the labour operating the machinery is not of a high class." " Immunity from breakdown is an important point."

Garner emphasises the value of roller bearings in a saving of 40 per cent. in power consumption.

Conclusion.—I hope sometime to collect information from different estates on the question of output of machines in the case of both crepe and sheet rubber.

This information will be acquired by sending a Questionnaire to estates and I hope that estates will send replies. Such a Questionnaire will be simple in character and will not contain any questions which will be difficult to answer, but only a little care in ensuring that the information is accurate.

Probably a number of efficient estates already have such information available, although not, possibly, in the detailed form which may be required.

I should like to emphasise here the value of information acquired in this way, to those of us who are carrying on applied research or investigations of this nature.

We are in the position of the judge or jury in sifting evidence, being able on such evidence to give a considered opinion on the best methods to be adopted. Such information can of course be acquired

by us by spending a considerable time in a number of factories and finding out the information by measurement and observations. This, however, is a more costly and laborious procedure and would be carried out in only a few instances to confirm the evidence obtained in the replies to a Questionnaire.

The value of a Questionnaire of this kind or rather of the replies received, has been realised in the case of the Questionnaire which we have adopted in connection with the preparation of sheet and crepe rubber on estates. In a large number of cases these replies have enabled us to give recommendations which have proved effective without the waste of time and cost of visiting the estate concerned.

I hope that this brief sketch of the problem has indicated that it is of some importance among the other problems of estate economics and that the Rubber Research Institute is interested and can assist and advise on such problems.

It is hoped as soon as possible to publish information in the form of a Manual or otherwise in connection with this problem and on the general design of factories, lay-out and type of machinery, drying rooms and smokehouses.

Information from estates is of great value in this connection.

(*Note.*—This paper was given as a lecture at the Annual Conference of the Incorporated Society of Planters at Ipoh on August 13th 1929).

BLOCK 6. MANURING EXPERIMENT, R.R.I. EXPERIMENT STATION.

FIRST REPORT.

By

W. B. Haines.

Purpose of the Experiment.

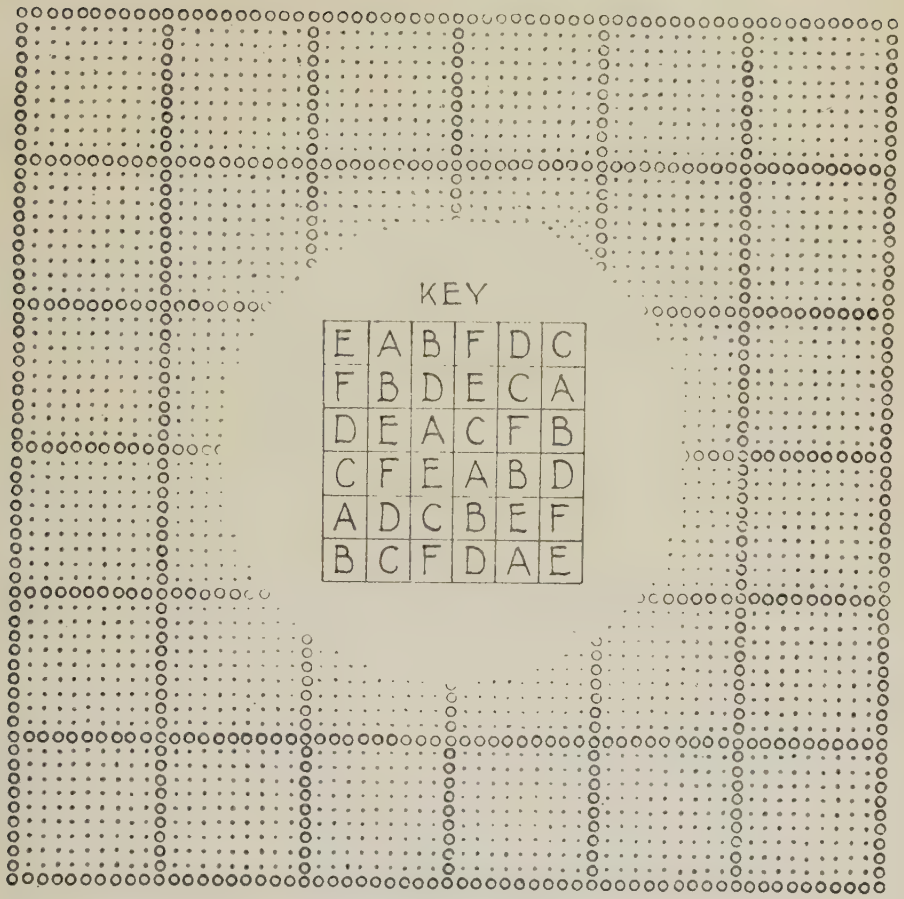
Block 6 of the Experiment Station of the R.R.I., consisting of 40 acres of uniform flat land, is laid down to an experiment to test the economic advantages of various forms of manuring under ordinary estate conditions. To this end the planting material chosen was ordinary "stumps" of good quality, and as regards the manurial applications it is intended as far as possible to limit them to such treatments as would be feasible for extensive application in estate practice. The need for more extended scientific information will be taken care of in other experiments not limited in this way.

The soil contains between 80 to 90 per cent. sand to a considerable depth. It may therefore be looked upon as a good physical medium for tree growth after the young stages are passed, but it is likely to show food deficiencies which should throw manurial effects into sharp relief. In spite of the level and porous nature of the ground the water during rain caused a good deal of surface movement, and bunding in squares had to be undertaken. The spoil for these bunds was won from narrow deep trenches which were allowed to fill up by wash. This gave a maximum of subsoil for the bund. A partial cover in addition may be found necessary, in which case it will be regarded as a necessary part of the "estate practice" conditions laid down, although not the best from the point of view of a simple manurial experiment.

Lay-out of the Experiment.

Five treatments in addition to control have been chosen for the test, and the plan of the plots is that of the Latin square. The planting is 22 ft. × 22 ft. (i.e. 3 trees to the chain). The 40 acre square block is therefore conveniently divided up into 36 square plots by means of the outside boundary rows and every 10th row in each direction. These trees are not regarded as in the experiment, the experimental plots being blocks of trees 9 x 9, separated from one another by the boundary rows. The treatments are so arranged to meet the requirements of statistical methods of handling the results that each treatment occurs once in each row of plots whether regarded

BLOCK 6. (40 ACRES)



TREATMENTS:

A Control.
B Complete Organic.
C Complete Inorganic.
D Nitrogen only.
E Nitrogen and phosphorus.
F Phosphorus and potassium.

FIG. 1.

from N. to S. or E. to W. With this restriction the assignment of position is at random.

Fig. I shows the lay-out diagrammatically.

The five treatments are as follows:—

A. Control.

B. Complete organic.

C. Complete inorganic.

D. Nitrogen only.

E. Nitrogen and Phosphorus.

F. Phosphorus and Potassium.

The first treatments were given at the time of planting at the end of October 1928. Appropriate mixtures were made up from ammonium sulphate, double superphosphate and sulphate of potash, carried to the field in wooden buckets, and measured out with a tin scoop for mixing with each heap of soil that had been prepared for filling the planting holes. The amount per stump was between $\frac{3}{4}$ and 1 oz. of fertiliser. Matured cowdung, $\frac{1}{2}$ gallon per hole, was used for the B. plots.

The weather immediately following planting was favourable but dry weather soon set in and for the first nine or ten months growth was badly retarded by unusually dry conditions. The type of soil, of course, much exaggerated the effect on such young plants. A second application of fertilisers was made on July 30th and 31st, 1929. The amount given was double the first dressing, and "Nitrophoska" was used on the C plots.

Results of First Treatment.

Measurements of height of each individual tree were made on September 18th, 1929. The second manuring was then so recent that the differences may be attributed mainly to the effects of the first treatment. For the measurements a staff was used, marked off in divisions of 3 inches each. The spaces were numbered serially and served to indicate the size class into which each tree fell.

A striking feature of the measurements is the uniform frequency of distribution over a wide range of size. Instead of the normal marked concentration of numbers round the modal value there was shown almost equal numbers of trees in each class over a considerable range. Table I gives the frequency data, including boundary rows.

Needless to say the planting was from a single batch of stumps from the same nursery, so that the population considered was derived from the same batch of seed grown in close juxtaposition. Later results may thrown further light on this unusual feature, which is for the present merely noted.

TABLE I.

Size Classes.	Number of Trees.
0—1′ 6″	37
1′ 6″—2′ 0″	113
2′ 0″—2′ 6″	297
2′ 6″—3′ 0″	334
3′ 0″—3′ 6″	324
3′ 6″—4′ 0″	295
4′ 0″ 4′ 6″	307
4′ 6″—5′ 0″	306
5′ 0″—5′ 6″	328
5′ 6″—6′ 0″	260
6′ 0″—6′ 6″	228
6′ 6″—7′ 0″	231
Over 7′ 0″	661
Total	3,721

Table II gives the average height of each group of 81 trees forming the plots.

TABLE II.

Averages of Rows	Average Height in Inches.					
	E	A	B	F	D	C
58.6	57.9	61.4	61.6	55.5	56.2	59.1
	F	B	D	E	C	A
59.3	61.3	61.8	57.0	59.6	61.5	55.5
	D	E	A	C	F	B
59.8	66.2	56.6	58.8	50.4	57.4	69.2
	C	F	E	A	B	D
56.7	57.1	58.6	55.0	54.3	58.7	56.8
	A	D	C	B	E	F
58.3	56.4	56.1	59.1	63.0	60.7	54.6
	B	C	F	D	A	E
58.6	57.6	58.8	61.0	60.4	54.8	59.0
Averages of Columns.	59.4	58.9	57.7	57.2	58.2	59.0

Arranging the values for each kind of plot in Table III we obtain the average for each treatment. These are also expressed in terms of percentage comparison with the average for the controls.

TABLE III.

	A. Control.	B. Complete Organic.	C. Complete Inorganic.	D. N. only.	E. N. & P.	F. P. & K.
	61.4	61.6	59.1	56.2	57.9	55.5
	55.5	61.8	61.5	57.0	59.6	61.3
	58.8	69.2	50.4	66.2	56.6	57.4
	54.3	58.7	57.1	56.8	55.0	58.6
	56.4	63.0	59.1	56.1	60.7	54.6
	54.8	57.6	58.8	60.4	59.0	61.0
Average for Treatment.	56.9	62.0	57.7	58.8	58.1	58.1
Percentage Comparison.	100.0	109.6	101.4	103.2	102.1	102.1

We may conclude that dung has proved the best treatment with a nine per cent. greater growth than the controls. All the other treatments show some benefit, although so small that it is not possible to discuss their relative merits as yet.

The history would indicate that such treatments as helped to resist drought would have shown best, but the set-back was so severe as to hinder all growth on all plots for a large part of the period covered.

The data are here presented as a preliminary announcement merely. In view of the probability that a further series of measurements in a few months' time are likely to show more distinct contrasts, this present series is left without more detailed analysis. The figures will also have greater value after receiving the corrections which will follow from a disease-inspection survey and the provision of the necessary "supply" plants.

THE ROLE OF HUMUS IN TROPICAL SOIL MANAGEMENT.*

By

W. B. Haines.

When the composition of soil is examined we find that the most clearly defined division between its constituents is that which classes them into organic and inorganic groups. Both of them represent the products of Nature in that half of her activities which is concerned with decomposing and breaking down. The inorganic or mineral part of the soil is the product of slow age-long processes of weathering of rocks, and has a comparatively simple type of chemical structure. The organic part of the soil, on the other hand, is produced by a much more rapid decay of dead animal or vegetable matter, and it still has the complex chemical structure characteristic of its living period. The much more rapid changes which the organic material undergoes brings it into prominence, for otherwise it is not usually present in large proportion. For the same reason it is only found in the upper layer of the soil, that is, near the region of its source of renewal. The term humus is loosely applied to this soil organic matter. In the later stages of the decomposition, the original organic structure is lost and a dark jelly-like substance remains which has fairly uniform characteristics. The more strict use of the term humus is confined to this end-product.

The unceasing change of the soil humus in its disappearance and renewal as compared with the relatively static nature of the mineral part of the soil, is the main point which it is desired to bring out here. The art of soil management must in the main accept its fate as regards the mineral basis upon which it has to work, the only rapid changes which are to be feared being actual movement under eroding influences. But a very considerable influence may be exercised on the humus status of the soil by judicious or injudicious handling. This is particularly so in tropical climates, where the processes of humus production and decay are so much accelerated. We have to consider the factors which influence these processes.

Let us first recapitulate the important functions which the humus performs in the soil. In the first place it is capable of the release of energy during its process of decay. This is essential for the support of the swarming microscopic fauna with which every fertile soil abounds. These creatures have a very complex world of change and interchange of their own, but their usefulness can be simply stated. They prepare the food material latent in the humus into forms which

*This article represents the substance of a lecture given before the Annual Conference of the Incorporated Society of Planters, Ipoh, August 13th, 1929.

plant roots can again absorb and utilise, and they render available by their manufacture the most important of all plant foods—nitrogen. But without organic material on which to feed, the majority of these micro-organisms can no more function than they could without air or water.

The presence of humus confers very important physical properties on the soil. Being dispersed among the mineral particles it alters their cohesion and makes the soil more friable and easy to cultivate. By its great affinity for water it increases the water retaining power of the soil, so that crops are able better to resist drought. Also, by this improvement in tilth the drainage and aeration are improved, so correcting the harmfulness of the opposite extreme of too much water. In this way humus acts as a buffer, absorbing the shock of two extremes and conserving the useful middle course.

In a chemical sense also, humus acts as a buffer—a word which has come to have a very specific use for an action which at once stores and stabilises. Both useful and harmful compounds can be stored or absorbed by humic material, in the one case saved from loss by leaching and in the other case the bad effect on the soil reaction suspended or nullified. Here again the humus is acting as a valuable intermediary in the soil changes.

The humus probably has other important interactions in the soil which can at present only be guessed at. Suffice it to say that the effects of humus have sometimes been even more far reaching than seems explicable by the simpler facts above cited.

The decay and disappearance of humus is constantly going on, so that from the point of view of the practical man we must consider what balance can be struck by providing for a constant supply. The humus status of the soil is similar to the financial status of a man—a constant steady unavoidable drain on the debit side requiring constant effort to add to the credit side and to maintain solvency. A man's personal banking account does not stand still so long as he remains alive, nor does the humus status of the soil cease to fluctuate according to the changing balance between decay and renewal. This analogy may be usefully developed by the reader to aid in realising the rapid and inevitable change in fertility value of the soil according to the policy of management. Agricultural returns are accompanied by humus consumption, while humus conservation must be at the expense of some outlay or sacrifice of immediate return. On every side one may see in tropical cultivation the soil bankruptcy which has been produced by extravagant management, careless of the future.

Consider first the ingoing side of the balance sheet. Under virgin conditions this consists entirely of the detritus shed by the natural vegetation. This will vary in amount according to the rate of growth, depending mainly upon climate and the basic fertility of the soil. Under cultivation the upkeep has to be attended to. Humus

may be added directly in the form of dung and of some of the organic fertilisers, or it may be added as a green manure crop grown for the express purposes of ploughing in. Although the removal of the crop from the land depletes what would be a potential source of humus, there is a compensating factor in the more rapid turnover produced by cultivation. The efforts spent in producing more vegetation as a crop from a given area tend also to increase whatever part is returned to the soil.

On the debit side the process of humus oxidation and disappearance is incessant. It is influenced very much by climate, and very much by the degree of aeration of the soil. Since the decay is accompanied by the release of plant food, the art of intensive cultivation is usually directed to hasten decay, but the balance must be maintained by increasing the organic input also. Rubber planting cannot be regarded as intensive cultivation in this sense except perhaps for the early period of forcing young rubber into the earliest bearing. Normal conditions approach more nearly the balance of the forest. The curves shown in Fig. 1* will throw some of these points into clearer relief. It represents the two curves of " earning " and " spending " for the soil humus as affected by the factor of temperature. Both curves are seen to rise with temperature until an optimum value is reached, and then to fall off again. The temperature becomes too high in the one case for plant growth which supplies humus and in the other for the bacterial life which destroys humus in the soil. The important thing to notice is that the optimum value for decay is higher than that for production. Since the values concerned are those reached in the tropics this has the geatest importance for tropical agriculture. The effective climate may be much altered by clearing operations, and we can examine what the result will be.

Measurements made at the Rubber Research Institute give an average temperature of 76°F. for the conditions under forest, and 88°F. for the temperature under cleared conditions. These are soil temperatures which may be regarded as the best basis for a discussion of the case. On the diagram are shown the two ordinates for these temperatures. At the lower temperature the rate of production exceeds the decay while the reverse is the case at the higher temperature. This means that in the one case the humus reserve is safe, but in the other is doomed to extinction. It requires nothing more than this to indicate the sudden and complete change in soil history which is brought about by felling jungle. It shows the fundamental process behind the well known deterioration of tropical soils when cleared and subjected to continuous cropping. Without special precautions the humus is bound to disappear entirely.

*The original curves on which this diagram is based are given by E. C. J. Mohr in "De Grond van Java en Sumatra."

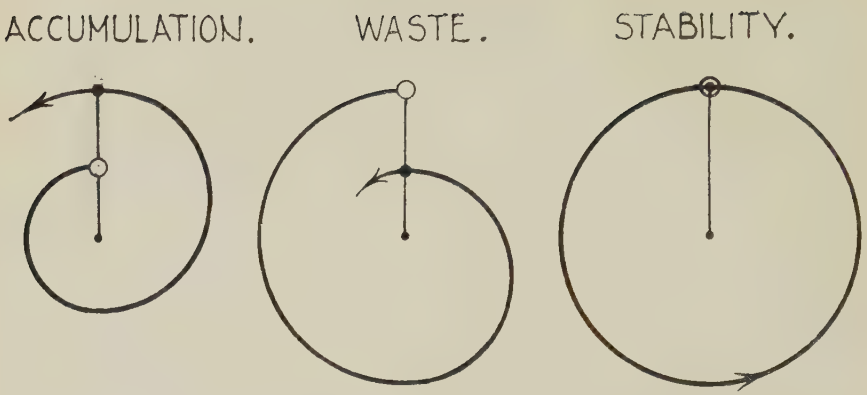

ACCUMULATION.
WASTE.
STABILITY.
PEAT.
CLEARING,
CROPPING,
CLEAN WEEDING.
VIRGIN LAND.
GOOD MANAGEMENT.

FIG. 12.

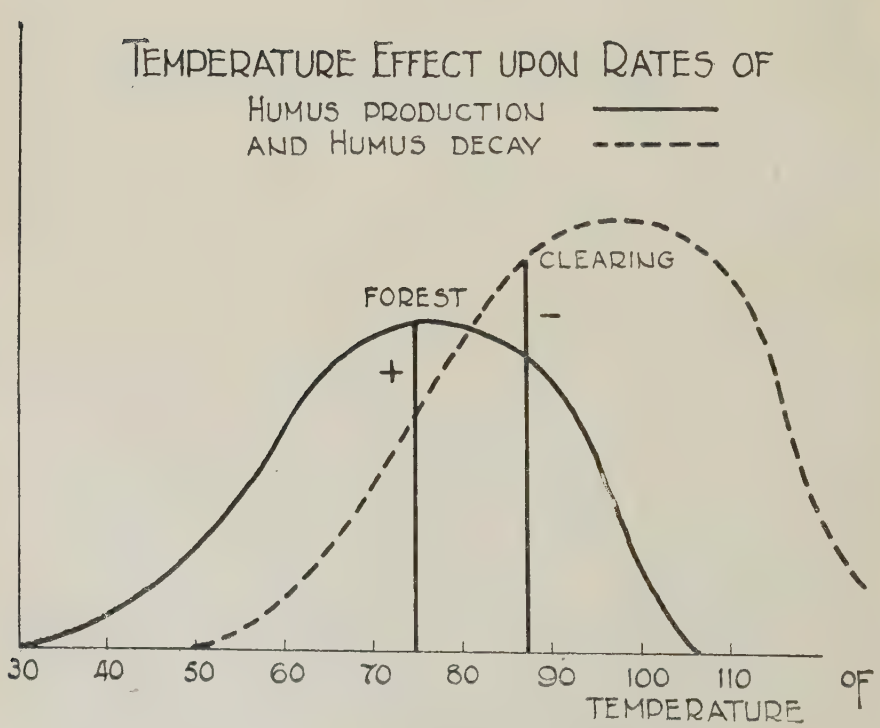

TEMPERATURE EFFECT UPON RATES OF
HUMUS PRODUCTION
AND HUMUS DECAY
FOREST
CLEARING
+
−
30
40
50
60
70
80
90
100
110
°F
TEMPERATURE

FIG. 13.

The main precaution possible under the conditions of planting rubber is to reduce the soil temperature by means of a low-growing cover. If the curves can be assumed to be accurate the reduction in temperature produced by a good cover is just sufficient to reach the neutral or balancing point. The reduction in the rate of humus decay, of course, reduces also the release of plant food. This opens up an interesting problem which will take time to solve. Earlier maturity of the rubber can be induced in some cases by the more extravagant cultivation policy of clean weeding, but it remains to be proved whether this gain is worth while in view of the loss of soil capital. It may also be suggested that forcing of early maturity might be less expensively done by means of artificial manures. On a good site where the leaf-fall from the trees regains something approaching the original forest conditions, no great harm may be done by a temporary extravagance, but in other cases it may be a matter of great expense and trouble to make good the humus depletion following clean weeded conditions under young rubber. The falling part of the vegetation curve also suggests that clean weeding might produce temperatures above the optimum value for rubber, so that the benefit from extra food supplies might be lost. This is another point requiring investigation.

We can now translate these main features into a diagram of another type shown in Fig 2. Here the changing humus status is shown by a radius vector which moves round a centre. Rising humus will give an increasing radius and an outgoing spiral. The falling humus of the above clean cleared conditions gives an ingoing spiral, approaching extinction. The third case of stability gives a circle, and the size of the circle will be a preponderating factor in deciding the fertility. The first case of permanent accumulation of organic material arises mainly where excess moisture has depressed aeration and humus decay, and gives rise to peat. The accumulated material sometimes builds up dams which exaggerate the swampy conditions and produce peat bogs. Drainage of the peat at once improves aeration and changes the nature of the case to the second type—an ingoing spiral. This is the danger point to be kept in mind. It means the extinction of the humus unless balance can be restored. On peat lands the process of loss can go on for very long periods without loss of fertility, because of the immense store, but other troubles ensue that are too well known to the rubber planter. The disappearance of the humus results in a fall of the soil level, leaving the roots of any permanent crop badly exposed.

Clean weeding is put down as one of the factors tending to the ingoing spiral, since it tends both to lessen the humus supply and to hasten its decomposition by exposure. In rubber under ideal conditions (where the true forest cycle is attained) this may not be important, since the main crop by its leaf-fall keeps up the humus supply.

But under less favourable circumstances weeding has often greatly hastened deterioration of site conditions.

The third case is the balanced one in which a circle is traced out. This must always be the ultimate case in rubber at any rate and the stable position may be a high or a low one. The aim of good management is to see that the ultimate circle is as large as possible. Intensive cultivation may also aim at making the circle revolve faster, getting a gain on the same principle as a business that makes its capital turn over more rapidly. That case scarcely arises for rubber. All that the rubber planter can do is to seek stable natural conditions under which the production of humus is a maximum and all possible conservation is attained. The main feature is the prevention of surface movement and consequent loss of leaf-fall. A close observation of what happens to the leaf-fall on his estate may well be recommended to every planter as an index pointing to what may need to be done to conserve the humus supply. Where deterioration has gone far the leaf-fall may have become very sparse and recourse may be had to the aid of covers. In one of the best known successful cases mimosa was grown under arrested rubber. The soil changes so induced caused a stimulation of growth in the rubber much greater than artificial fertilisers had done. The normal balance was then quickly attained by the rubber overshadowing the cover, which practically disappeared.

FUNGI AND DISEASES OF THE TAPPING PANEL.

By

F. Beeley.

Introduction.

In our concept of health the importance of thrifty development has been universally recognised. The conditions necessary for a thrifty development of any crop may differ somewhat in detail but in general terms they may be enumerated as follows:—

1. The proper inherent qualities of seed or stock from which plants are to be grown. Seed and stock should be selected from plants which have proved to be least susceptible to disease.

2. The proper environmental conditions of both air and soil—proper moisture, temperature, and light relations; proper physical and chemical composition and aëration of soil. An efficient drainage system is essential, so that danger from accumulation of toxic or poisonous substances may be minimised and food materials rendered more easily available to the plant. For any given variety of plant there are certain optimum conditions of moisture, temperature, light intensity and soil relationships which will give the best development of that plant. Should those conditions be allowed to fluctuate above or below the optimum then the life processes of the plant may be slowed up resulting in loss of crop and weakening of tissues so that they become less resistant to disease, or as for example, the asphyxiation of rubber trees in the flood areas of Pahang and other districts, death may take place within a short time.

3. Freedom from mechanical injuries. In the case of the rubber tree it is necessary to make an extensive wound in order to withdraw the crop.

4. Freedom from the depredations of parasites either animal or plant.

It is chiefly with the latter two conditions that this paper deals, but it should be remembered that condition (2) above is a very important factor in the prevention and control of diseases of the tapping panel. The maintenance of proper growth conditions combined with a high standard of estate sanitation are of the greatest assistance in prevention and control of diseases of the rubber tree.

Present Work.

In order to meet the requirements of the planter it was felt that a paper in collective form describing the incidence, diagnostic symptoms and methods of control of the various diseases of the tapping

panel was necessary. Much excellent work on Patch Canker, Black Stripe and Mouldy Rot has been done in the past by scientists in the more important rubber producing countries. This work is incorporated in concise form in this paper together with further work by the author on the fungus species *Ceratostomella*, on fungi concerned in Die-Back and Sun-Scorch of the tapping panel and some observations on the disinfectants used in the control of diseases of the tapping panel.

CLARET-COLOURED OR PATCH CANKER OF HEVEA.

Occurrence.

This disease is most prevalent in the low-lying coastal districts of Malaya where a heavy foliage combined with showery weather produces at times a serious outbreak of the disease. It was first reported on Hevea in Ceylon in 1903 and since then has been reported in practically all the rubber growing countries of the East and in the Amazon region.

Symptoms.

In the early stages the disease appears as a dark stain penetrating the bark of the tree and may appear on any part of the main trunk from the ground level to the first fork. On mature brown bark the dark patches may be difficult to observe until a point is reached when the bark of the patch becomes finely cracked and a purplish liquid is exuded which quickly dries in small dark streaks as it runs down the trunk of the tree. The diseased patches may at this stage become attacked by borers, but many advanced cases have been observed where borers have not been present.

The disease begins from the outer living layers of the cortex and works inwards to the cambium and wood, spreading usually more rapidly downwards than horizontally. On the tapping panel it has been observed frequently to commence in the higher renewing bark and to spread obliquely downwards across the cut, where it resembles a serious localised attack of Black Stripe, into the untapped bark well below the cut. Large areas of bark may thus become affected, though an instance of complete ringing and death of the tree by this disease has not been observed by or reported to the writer.

The colours of the affected tissues are very noticeable. The bark normally has three distinct colour regions, the outer brown and corky, next a narrow green zone, which in the case of renewed bark is usually red, and a wide inner yellowish to white zone near the cambium. The diseased tissues, however, in the early stages become drab grey, and later purple red streaked with grey. The affected wood beneath the canker may also be similarly discoloured.

Causal Fungi.

The fungi associated with the disease according to Thompson (2) are *Phytophthora palmivora* Butl, and an unknown species of *Phytophthora*, closely allied to *P. Meadii* McRae, and a species of *Phythium*, any one of which may directly cause the disease Patch Canker.

The disease is prevalent on susceptible areas particularly during wet and especially in prolonged showery weather. On the advent of dry weather the disease ceases to spread, the old, moist, cankered bark dries up and scales off or is cracked off by the presence of the callus produced at the extremities of the wound area. The fungus becomes active again as soon as conditions become suitably moist; spores are blown about by the wind, splashed by rain, or carried by other external agents to fall on neighbouring trees whose bark may be sufficiently moist to promote growth of the fungus and production of a canker within a few weeks.

Control.

First of all it should be remembered that dense planting maintains extremely moist conditions, and prevents rapid drying of the tree trunks after rain. Thinning out should therefore be adopted as a first control measure on estates or areas where the disease is very troublesome.

Individual trees should have all diseased discoloured cortex removed, the excised bark being carefully collected and burned. It is not necessary to excise any wood unless a decay has set in, as might be found in old neglected cases. Having cut out all discoloured bark and a margin of an inch or so of apparently healthy bark the exposed tissues should be sprayed with a 10 per cent. solution of Brunolinum plantarium, 5 per cent. Izal or 10 per cent. Agrisol. Where the wounds extend right through to the wood the exposed wood should be painted with Asphaltum-kerosene mixture in order to prevent attack by borers. The Asphaltum-kerosene mixture consists of equal parts by weight of asphaltum and kerosene heated together and allowed to cool. Tar has been used in the treatment of Patch Canker, but it should be remembered that any treatment is useless unless the diseased tissues have been cut out.

A keen watch should be kept on all tapping panels in districts where the disease is known to be prevalent, so that if an infection is observed it may be treated in its early stages, and thus avoid wounds to the wood on a part of the tree where bark is necessary to obtain the crop.

The fungi concerned in this disease are known also to produce a disease of Hevea pods. The fungi hibernate in the pods which remain pendant upon the tree out of season, and when weather becomes

suitable the fungus grows out and provides spores for infection of the stems.

BLACK STRIPE DISEASE.

Occurrence.

A disease of the renewing bark of the tapping panel occurring to a greater or less extent in all rubber growing countries of the East is known by various synonyms. The terms Black Stripe, Stripe Canker, Black Line Canker, Black Thread, Bark Rot, and Cambium Rot are all terms describing the one disease of which the term Black Stripe is parhaps most appropriate and most descriptive of the usual early effects of the disease on the panel. Though first reported in Ceylon in 1909 (1) there seems to be some doubt as to the date of its first appearance in Malaya. The first definite outbreak of Black Stripe appeared in North Perak towards the end of 1916 (3) and soon became generally distributed throughout the plains of Malaya. The disease seems to be more prevalent in the low-lying peat soils where a heavy foliage maintains more favourable conditions for the hibernation of the fungus.

Symptoms.

The disease may be first noticed during tapping operations in the form of short, vertical, fine, black lines in the freshly cut tissues immediately above the cut and extending radially outwards on the surface of the cut giving the appearance of a dark or black letter "L". As tapping is continued these black lines become more numerous and are often to be found in groups of three or more on the cut. In a short time, under sutiable moist conditions, the lines coalesce and may be seen as dark vertical depressed stripes extending from the cut to as much as two or three inches above it. On cutting away the renewing cortex the stripes will be observed to broaden out and to continue into the wood where a dark area traversed by several very black vertical stripes corresponding to the group of dark lines in the cortex may be found. As the disease progresses, the lines in the cortex extend laterally eventually joining up to form an elliptical patch of depressed cortical tissue from which latex or a purplish fluid may ooze out. In some districts conditions are seldom such as to promote further advance of the disease so as to involve large areas of the panel. Dry weather quickly arrests the disease and a callus is formed around the edges of the wounds. In districts where Black Stripe is of frequent occurrence several rows of such healing wounds may be observed on the panel, each row corresponding to that part of the panel which was tapped during the wet months of the year, i.e., at a time when the disease was active.

Further advanced stages of the disease may be found in certain coastal districts where the rainfall is such as to maintain the bark of the tree in a wet condition over a period of two or three months. In such cases the disease may affect a wide band of tissue above the cut while the untapped bark may become affected to a distance of six inches below the cut. This is evidenced by the formation of large pads of coagulated latex between the cortex and wood which gradually increase in size causing a vertical split in the affected cortex. Similar smaller pads may be observed above the cut. This coagulated latex and other exuded fluid soon begin to ferment and the wounds assume a foul smelling black ruptured decaying condition. Such cases are, however, rare and are usually the outcome of neglect or incorrect treatment.

Slight variations from the above general symtoms may be found. On wet mornings during showery weather a delicate white bloom may be seen immediately above the affected cuts. This bloom consists of mycelium and spores of the parasitic fungus together with those of *Fusarium* and other secondary fungi and bacteria. The presence of a white fungus on the panel may lead to an incorrect diagnosis of an early stage of Black Stripe as Mouldy Rot. In the case of Mouldy Rot the bloom is closely adpressed to the tissues while in Black Stripe the bloom is aerial and of a silky nature. The penetration of the fungus into the tissue seems to vary from the normal in some cases. It may be superficial or may penetrate deeply into the wood; the black lines may coalesce rapidly or may remain as broad stripes. These variations may be due to the species of fungus present and to the conditions of temperature and moisture under which it is working. These conditions may also be responsible for the varying descriptions of the disease in the different rubber-growing countries.

Causal Fungi.

According to Thompson (2) three species of *Phytophthora* are directly responsible for Black Stripe disease of Hevea, in Malaya, i.e.

(a) *P. palmivora* Butl.
(b) *P. Meadii* McRae.
(c) *P. Heveae* Thompson.

Thompson states that these species are not all confined to Black Stripe disease, *P. palmivora* Butl. has also been obtained from naturally occurring Patch Canker, and *P. Heveae*, Thompson, from naturally occurring pod-rot.

Further, inoculation experiments have shown that other species of *Phytophthora* can cause the disease and will probably be found to attack the bark and fruit of the rubber tree in the near future.

The taxonomic details of these species of *Phytophthora* are of no direct interest to the planter. Factors in the growth and method of spread of the fungus are, however, worthy of attention. Assuming the renewing bark to be diseased it has been observed that, without high humidity, external mycelium is not produced, sporangia do not germinate, while zoospore production takes place only in the presence of water. In districts of heavy rainfall and consequently relatively high humidity the production of sporangia and zoospores takes place rapidly, and these may be splashed by rain or carried by external agencies to other trees where infection of the cut may easily take place, while the disease may ravage the individual panels to a greater extent than would normally occur. Any factor which tends to increase the humidity of the atmosphere around the trees should be well considered before adoption. Close planting, growth of luxuriant cover crop around the base of the trees and bad drainage all tend to increase humidity and should be avoided.

The tapping knife and the tapper's hands are perhaps the chief factors in the spread of the disease.

Control.

From the foregoing paragraphs it will be evident that any attempt at prevention or control of Black Stripe disease must be preceded by an amelioration of the conditions under which the rubber tree is growing, if success is to be attained. Ring weeding of trees, thinning out densely planted areas, elimination of high cover crops, seedlings and *belukar* and improvement of drainage will promote a more rapid drying of the bark after rain, and are to be recommended.

Estates in areas where the disease is known to be prevalent may, during wet weather, adopt a system of preventive painting of the freshly tapped cut after each tapping with a dilute solution of disinfectants such as 2—3 per cent. Izal, 5 per cent. Brunolinum plantarium, or 5 per cent. Agrisol. The disinfectant is carried by each tapper and applied by means of the finger or a rotan brush at the time of lifting the latex.

A close watch should be kept during wet weather and as soon as the disease appears all the panels in the affected area should be painted with a preventive disinfectant solution. Take out of tapping all affected trees, remove the scrap rubber, clean the vertical channels and spray with disinfectant solution every alternate day for one or two weeks. Izal (5 per cent.) and Brunolinum plantarium (5—10 per cent.) have given good results in curative treatment of Black Stripe. Tapping may be recommenced on the original cut after one month, when preventive painting should be carried on for a time until danger of re-infection disappears.

Immediately an area has become infected with the Black Stripe fungus all knives, scrap sacks, spouts, and cups should be sterilised and cleaned in disinfectant solution. Tappers from affected areas should not be transferred to other areas until knives and utensils have been sterilised.

In view of the fact that spores are washed down by rain the area of the panel to be disinfected should include a region of at least six inches of untapped bark below the cut as well as the vertical channel. If the cut is very low it is advisable to spray down to soil level. The use of a small sprayer is recommended as being more economical and gives a more efficient penetration of the interstices of the bark.

If the presence of the disease has not been noticed for some time, and the panel has become badly mutilated with wounds and cracks due to the formation of pads of coagulum between the bark and the wood, it will be found necessary to excise a certain amount of cortex. The presence of foul, fermenting, sodden bark and coagulum has a deleterious effect on the healing of wounds, consequently such wounds should be cleaned to the wood if necessary, taking care to excise as little healthy tissue or callus as possible. Spray with 5 per cent. Izal or Brunolinum plantarium, allow to dry, then paint over the affected area of the panel with a solution of equal parts of solid asphaltum and kerosene.

All scrap rubber from wounds of this type is very infectious and should be carefully collected and burned.

The application of strong disinfectants has been observed to damage the panel almost as much as the disease itself and is to be avoided. Cargilineum mixture B. (10 per cent.) has been used successfully in the control of Black Stripe in Ceylon, and has been used with some success against both Black Stripe and Mouldy Rot in this country. It should be applied only to the dry panel preferably in the afternoon. If no extensive wounds have formed it may be used at the rate of three applications with a four day interval between each. Applied on the affected region, above and below the cut, it forms a good water-proof, durable, disinfectant cover.

In all cases where the affected tapping cut is very low it is preferable to open a fresh cut on another section of the tree rather than to reopen the original low cut, owing to the danger of re-infection from the soil.

On several occasions the writer has visited estates where the disease has been in a resting form, and the wounds evident some four inches above the cut have begun to heal. It is useless to apply the above treatments in such cases, and all that may be necessary is to clean out the decayed bark in the centre of the wound, excising as little callus as possible, then paint over the wood with the asphaltum solution previously mentioned. A close inspection of such an area

should be kept in order that in the event of the fungus travelling down the wood behind the healthy cortex and reappearing on the cut in wet weather, immediate treatment on the lines above may be carried out.

As in the case of Patch Canker organisms, the fungi which cause Black Thread may hibernate in pods, branches or rubber wood lying about on the estate. Such material should be collected and burned and highly sanitary conditions maintained throughout.

MOULDY ROT OF THE TAPPED PANEL.

Occurrence.—

The disease was first recorded from the Seremban district of Malaya in 1916, during a wintering season of continuously wet weather. Since then, however, it has become prevalent to a greater or less extent throughout Malaya.

South and Sharples (7) state "No information has been obtainable to show how the disease originated. Its first occurrence in one "definite limited area suggests that the fungus may have been imported "on another host plant and from it may have spread to the tapping cuts "of other trees. If the fungus was originally native to the Peninsula, "living on one or more other hosts and if it had spread from these "and adapted itself to living as a wound parasite on the tapped bark "of rubber trees, such adaptation would probably have occurred in "many separate localities at about the same time. Actually, however, "it is fairly certain that the disease spread from one originally infected "area and was conveyed from one locality to another by human "agency."

This, however, does not definitely preclude the possibility of an alternative host. The fact that at least two species of Sphaeronema, very similar to the one causing Mouldy Rot, are to be found in Malaya supports the opinion that the Mouldy Rot organism is a morphological strain developed from a smilar species on other hosts. Mention of this will be made later.

The occurrence of Mouldy Rot on progressive estates is not common. In small holdings' rubber, however, where the dense planting and poor and deep tapping to get maximum yields is practised, the disease may often be found attacking as many as 75 per cent. of the trees. In such areas the presence of tall grasses and *belukar* tend to maintain within the area a condition sufficiently moist and cool to give an optimum vigour and growth of the fungus.

The disease is also prevalent in Java and Sumatra (12) and other rubber growing countries near the Malayan Peninsula. It has not, however, been recorded from Ceylon, where in all probability the seasonal changes of temperature and humidity do not favour the growth of the fungus as a parasite on the rubber tree.

Although it is more active during wet weather and in moist situations the fungus can withstand desiccation for a considerable period by means of its thick walled resting spores, and though growth is slow the disease may be observed to be present, to cause damage and to spread during drier weather.

Drought combined with high temperature is, however, unfavourable to the growth of the fungus, and may completely check an attack of the disease in the field without the aid of disinfectants.

Symptoms.

The first evidence of infection of the freshly cut surface of the panel is a localised darkening of the tissue about $\frac{1}{2}$ inch above the tapping cut. In inoculation experiments the darkening of the tissues appears within 24 hours of infection. This dark spot quickly enlarges and the surface becomes sunken so that in a few days several square inches may be involved. If the other infections have occurred in a line parallel to the cut, then these also extend in a similar manner and unite to form a dark band of sunken dead or dying tissues. The band of tissue thus affected may be from $\frac{1}{2}$ inch to 3 inches wide and may extend right across the panel, broken here and there by a strip of healthy tissue. There is always a strip $\frac{1}{2}$ inch to 1 inch wide of apparently healthy tissue immediately above the cut. The disease has rarely been known to extend below the cut, while the portion of the bark affected is usually 7 to 10 days old before the disease is visible.

Upon the dark band of dead tissue the fungus soon produces aerial mycelium and spores, and acquires a dense whitish "bloom" closely adpressed to the tissue. This "bloom" may vary in colour from the black of the rotting tissues visible on the outer margin to a grey green zone consisting mostly of fungal hyphae and a larger central white zone in which may be found the fruiting stages of the fungus together with other secondary fungi and bacteria which may be living on the dead tissues. The presence within the "bloom" of black pycnidia stalks surmounted by a pale gelatinous globule containing spores, the whole resembling a short pin, is a diagnostic character now not commonly met with, although in the past it was noted in practically every case by previous observers. This lack of pycnidia in nature may be brought about within the fungus as a result of a slow transformation process or it may be a result of the activities of bacteria and infusoria as may be observed in contaminated cultures of the fungus in the laboratory.

The extent and density of the Mould may vary considerably with environmental conditions. Cool moist conditions such as those obtaining in closely planted small holdings' rubber, inadequate drainage system and wet showery weather are factors which promote a more rapid growth of the fungus on the panel. Under these conditions the

fungus becomes easily visible as a wide band of white mould above the cut, while yet higher portions of the panel bear extensive wounds or black depressed sunken areas caused by the fungus completely penetrating and destroying the renewing bark. There is no formation of rubber pads beneath the diseased bark, nor is there a visible exudation of fluid as in Black Stripe. A very thin film of rubber may, however, be frequently observed covering the diseased tissues, but as this may also be found on quite healthy panels it cannot be regarded as a symptom of the disease. When the disease becomes inactive the dead tissue to the wood scales off on drying, a callus is formed on the edge of the wound, and a slow healing process commences. Repeated attacks of the disease each producing its zone of healing wounds in the renewing bark are blemishes of the panel which take years to cover, and even after such long periods the resulting panel is often so uneven as to make subsequent tapping without wounding almost an impossibility.

The serious consequence of the effects of the disease, the longer periods required for renewal of the weakened bark, the virulence and rapidity of spread and general epidemic tendencies of the fungus have caused the disease to be made notifiable by law. The disease is easily kept in check on well managed estates but in less easily accessible small holdings' areas the disease is often permitted to remain for considerable periods.

The assistance of neighbouring European estates in educating the small holders in the treatment of diseased trees will be of great benefit to all rubber growers and will also help to minimise the danger of infection which so often creeps into European estates from nearby neglected small holdings.

Causal Fungus.—

The fungus which causes this disease has been identified by Sharples et alia (3) as *Sphaeronema fimbriatum* (E. and H.) Sacc. A black rot of sweet potatoes has also been shown to be due to *Sphaeronema fimbriatum*. The rubber species and the sweet potato species of this fungus are alike in morphological and cultural characteristics, but inoculation experiments so far show that the rubber species will not attack living sweet potato tubers nor will the sweet potato species attack living bark of the rubber tree. There is, therefore, some physiological difference between the two strains. Elliott (9) has demonstrated the presence of asci and ascopores within the pycnidium of the Black-Rot Sweet Potato fungus and identifies the fungus accordingly as *Ceratostomella fimbriatum* (E. and H.) Elliott. Mycologists further claim that, despite the fact that the asci have not been observed in the pycnidia of the Mouldy Rot fungus, this fungus also should be regarded as *Ceratostomella fimbriatum* (E. and H.) Elliott. The writer in collaboration with Mr. Gunnery has examined

sections of young pycnidia of the Mouldy Rot fungus for the presence of asci but without success, although stages suggestive of asci production were observed. A photograph of one such stage is reproduced in this paper. (Plate VI, Fig. 1.)

Ashby (10) regards *Sphaeronema fimbriatum* as a synonym of *Ceratostomella fimbriatum*, and compares this Mouldy Rot fungus with *Rostrella coffeae* Zimm., found by Zimmerman (11) on the bark of coffee and with a similar fungus found as a wound parasite of pimento branches (*Pimento acris*) in Jamaica in 1917. He then concludes the same species of fungus occurs as a wound parasite of three woody plants, coffee, pimento, and rubber with an adapted strain parasitic on sweet potato.

These conclusions open up a wide field for investigation which will probably throw some light on the incidence of Mouldy Rot on rubber estates, and especially on small holdings where alternative hosts are easily available to the fungus. A further species of *Sphaeronema* (*Ceratostomella?*) is very abundant in all rubber growing districts, and may be found growing luxuriantly on freshly cut wood of Hevea. Up to the present no parasitic tendencies have been attributed to this species of fungus, though other workers have reported its occurrence on Hevea bark and on palms in Uganda, and on the coconut in Zanzibar and Seychelles (10).

This fungus also bears close resemblances to *C. fimbriatum* (E. and H.) Elliott, but although the ascopores (or pycnospores) are very similar, its apparant saprophytic nature, and the differences in growth and asexual reproduction would justify making it a distinct species.

However, until the presence of asci has been demonstrated in the life history of the Mouldy Rot fungus the name *Sphaeronema fimbriatum* (E. and H.) Sacc. must stand.

The mycelium of the fungus is at first greenish, but rapidly darkens to olive brown. The septate much branched mycelium grows rapidly under cool moist conditions. In the laboratory no further growth took place in living one day old cultures when placed in an incubator at 35°C. while most rapid growth occurred in similar tubes placed in an ice cooled chamber at a temperature varying between 22°C. and 26°C. Its growth at different temperatures, therefore, closely resembles that of *Ceratostomella fimbriatum* (E. and H.) Elliott from Black Rot of sweet potato. Cultures of both these fungi after incubating at 35°C. for one month failed to grow when again subcultured, showing that death had apparantly taken place.

Under suitably moist conditions the fungus grows rapidly. The first type of spore—the rod-shaped endoconidia (Plate IV. Figs. I and II)—is produced almost immediately and in a few days they may be visible as a dense white film over the surface of the tissues or medium. These hyaline endoconidia are usually attached in chains,

or, if excessive moisture is present, they form groups or masses of spores side by side. They vary in size, averaging 10.3 x 5.3 microns. Although they are killed within 24 hours by desiccation over calcium chloride, they can withstand the dryness of a room for nearly two months. The macroconidia (Plate III) are produced on the surface or within the substratum, on short lateral branches of the mycelium They are olive brown in colour, thick walled, spherical to elliptical with an average size of 16 x 13 microns. Oil drops may frequently be discerned among the cell contents. They can withstand desiccation for six weeks but are no more resistant to the action of disinfectants than the endoconidia. The endoconidia, therefore, are a more important factor in the spread and hibernation of the fungus than has previously been supposed.

The viability of the resting spores and endoconidia has been determined in the laboratory by both concentration and time-immersion tests, and although a fourteen days old living culture on living Hevea bark was used for the time-immersion tests it is thought desirable to publish the results of these experiments together with field experiments now in progress at a later date.

A third type of spore is produced within a black flask-shaped structure—the pycnidium. The lower portions of the pycnidium are usually embedded in the substratum, while the neck and upper half of the lower wide portion only may be observed to protrude from the surface growth. Masses of hyaline pycnospores produced in the base of the pycnidium are slowly extruded from the fimbriated end of the neck in the form of a pale gelatinous globule which turns brown with age. The spores within this gelatinous globule are frequently bowler-hat shaped, usually 4.5 x 2.5 to 3 microns, occurring singly or in pairs; these are mingled in variable proportion with oblong spores usually 5 x 3.5 to 4 microns, lacking an annulus, and thought by Ashby (10) to produce the bowler-hat shaped spores by division.

When fresh the pycnospores germinate almost immediately on a suitable medium; they cannot however withstand even a few hours' desiccation. It would appear, therefore, that the endoconidia and macroconidia are the chief means of spread of the fungus.

Other fungi associated with *Sphaeronema* on the tapped bark are as follows:—

1. *Fusarium sp.*—

Occurs in abundance in the microconidial stage in all cases of *Sphaeronema* Mouldy Rot so far examined by the writer. Although in nature the typical *Fusarium* spores of this species are rarely seen, they develop readily enough on synthetic media along with masses of the microconidia.

It belongs to the group *Martiella* of the genus *Fusarium*. It has been identified as *Cephalosporium sp.* by previous investigators.

2. *Diplodia sp.*—

Occurs in small quantities on diseased panels. It is considered of secondary importance only, although in association with Sun Scorch and Die-Back of the panel it has been observed to cause considerable damage.

3. *Penicillium sp. and Aspergillus sp.*—

These have frequently been observed, but are to be considered as saprophytes living on the diseased tissues.

4. *Bacteria and Infusoria.*—

Are always present to some extent and it is thought may parasitise the *Sphaeronema.*

5. *Actinomyces sp.*

Have been isolated from specimens of Mouldy Rot, and although the majority of members of this genus of fungi are common soil organisms a few are known which are of strong parasitic tendencies.

Prevention and Control.

From the foregoing account of the occurrence, method of spread and nature of the disease the importance of maintaining an open, healthy, dry atmosphere within the plantation will be realised. Less dense planting systems, good drainage, low-growing cover crops where a cover is necessary, ring weeding each tree, shallower tapping during wet weather, clean knives, cups, spouts and channels, and the occasional sterilisation of all utensils used in tapping are factors which tend to minimise the possibility of occurrence of the disease. Tappers coming from other districts may be a source of danger, and any tapping utensils which they may bring with them should be carefully cleaned and sterilised. This can be effected by boiling the utensils in a 5 per cent. solution of disinfectant such a Izal or Brunolinum plantarium.

On estates in districts known to have infected trees a preventive treatment of healthy trees by spraying the panel, after every third tapping, with 3 per cent. solution of Izal, Arboretas or Brunolinum, plantarium or 5 per cent. Agrisol may be practised during wet weather.

If the disease has appeared within the area the following methods of treatment may be adopted.

Firstly remove and burn all bark scrap before applying fungicide. Clean the vertical channel, spouts and cups, and overflowed rubber on the panel below the cut. Films of coagulated latex serve as a medium and protective cover for the fungus through which the disinfectant may not penetrate. Tappers on infected tasks should have their knives and utensils sterilised and all trees in other tasks tapped by the same tapper should be sprayed with one of the preventive sprays mentioned above.

Having cleaned the panel and burned all infective scrap material the disinfectant may then be applied. The method of application and area of panel to be disinfected requires careful consideration.

In cases where the disease has been present for several days or more it is likely that rain has washed numerous spores down into the interestices of the bark below the cut and on the bark near the vertical conducting channel. It is therefore almost useless to paint a narrow strip of the renewing bark, and the best result which may be expected from this method is merely that of temporary relief. Experiments in heavily infected small holdings have repeatedly demonstrated the uselessness of strip painting.

In order to eradicate the disease it is essential to spray all the panel to the ground from a point some 12 inches above the cut, and including the vertical channel. It will be realised that the use of a brush, coconut husk or rag will make this procedure somewhat tedious, wasteful of time and material, and ineffective. The most economical, rapid and efficient method is to use a small hand sprayer, or, if large areas are to be treated, a knapsack sprayer fitted with a fine spray jet. A fine spray will penetrate into the interstices of the bark and will enable the operator to cover a larger area in a given time, while the quantity of liquid used is less than by other methods and the disease is less likely to reappear owing to the more thorough disinfection of the bark.

It is desirable that all infected trees be taken out of tapping for one month, but circumstances may arise where tapping is essential to maintain the yields of the estate for commercial purposes, in which case freshly cut portions of the panels must be painted with disinfectant after each tapping following the proper treatment.

The following disinfectants may be used in the manner described :—

IZAL.

Use a 3 per cent. mixture of Izal in water and apply by means of a sprayer to the whole panel, giving three applications with one day interval between each. Rest from tapping for one month. If it is necessary to keep the trees in tapping give three applications on the whole panel as above, then paint over the freshly cut cortex each day for one month at the time of lifting the latex.

BRUNOLINUM PLANTARIUM.

Use a 5 per cent. mixture and apply as stated for Izal.

A little methylene blue (1 oz. in 10 gals.) added to the above colourless disinfectants will assist in checking the work of disinfection.

AGRISOL.

Use a 5—10 per cent. mixture in water and apply as for Izal. If the weather is wet, use the stronger mixture.

Brunolinum.

This is not miscible with water and requires 1 per cent. soft soap to render it miscible. The mixture is prepared by heating together 2 gals. of water and 1 lb. of soft soap, to nearly boiling point, then adding 5 lbs. of Brunolinum. Stir vigorously and dilute to 10 gallons.

This mixture should be applied as for Izal, except that it must be applied to the dry panel, preferably in the afternoon, after tapping.

Cargilineum B. Mixture (10 per cent.)

This is an insoluble compound withstanding wet weather. It is in paste form and cannot be applied by spraying; a brush must be used. Two applications, covering as much of the panel as possible, with an interval of 7 days, have given results equal to those obtained by using water miscible disinfectants as above. If tapping is to be continued the freshly cut cortex must be painted with the disinfectant each tapping day for one month.

In wet weather, or as an additional precaution, the water miscible disinfectants may often be followed with advantage by a coating of a waterproof disinfectant medium applied to the affected panel some 6 inches above and below the cut. Three such water proofing mixtures are as follows:—

10 per cent. Brunolinum in 90 per cent. Tar.
10 per cent. in Solignum 90 per cent. Tar.
Cargilineum Mixture "B" 10 per cent.

Any of these three mixtures may take the place of the third application of the water miscible disinfectant, and should be applied only when the surface of the panel is dry.

The itinerary for the control of Mouldy Rot on estates where efficient supervision can be given may be summarised as follows:—

1. Treat by spraying with an efficient fungicide.
2. Carry on preventive spraying.
3. Close the cuts of affected trees with a waterproof paint mixed with a fungicide.
4. Thoroughly disinfect all utensils, tools, cups, spouts and scrap sacks.
5. Keep unaffected trees in tapping but under close observation.
6. Make sure that every case is treated as soon as it appears.

On re-opening the panel after a period of rest it is not necessary to open a fresh cut a few inches below the old one. It is better to reopen tapping on the original cut. Tap less deeply at first and keep a close watch for a reappearance of the disease, and, if present, commence the necessary control measures at once.

WHITE FAN BLIGHT.

Occurrence.

This disease occurs on rare occasions on the tapped surface in many districts throughout Malaya where the rainfall is sufficient to maintain the bark in a wet condition over periods of several weeks. It is not of serious consequence, but is often mistaken for Mouldy Rot, and it was during the serious spread of the disease that the new disease White Fan Blight was first observed by Thompson (13) in 1924 and investigated by Sanderson and Sutcliffe (14) in 1924—1925.

Symptoms.

A white silky mycelium easily visible to the naked eye may be observed spreading fan-wise over the surface of the tapped portion of the panel. It appears to be very superficial yet closely adpressed to the surface. Distinct venation may be noticed within the fungal growth and, if the fungus is stripped off, the impress of these thicker vein-like strands may be observed to have produced corresponding grooves on the outer layers of cortex. Sanderson and Sutcliffe (14) state that the mycelium was observed microscopically to penetrate only as far as the cork cambium and that no damage had been done beyond a slight disfigurement of the outer cork surface.

The fungus usually commences growth from the corners of the extremities of the tapped panel where the moist, dead, scaling tissues seem to be favourable to the growth of the fungus. It is an extremely weak parasite and need cause no alarm. It does, however, indicate that conditions are such as to promote the growth of fungi on the panel and accordingly care must be taken to prevent other more strongly parasitic fungi from attacking the panel.

Causal Fungi.

There seems to be some doubt as to the name of the causal fungus. It was thought at first to be a *Marasmius sp.* but fruits of the fungus in pure culture obtained by Sanderson and Sutcliffe (14) were identified by Miss Wakefield (Kew) as *Collybia sp.* A photograph of the fungus on the panel is given. (Plate VI, Fig. 2).

Control.

The disease is easily checked by spraying the panel with a weak solution of disinfectant such as 2 per cent. Izal in water, 3 per cent. Brunolinum plantarium or 5 per cent. Agrisol in water. One such application should be sufficient but, if tapping has been deep and other fungi besides the *Collybia sp.* are at work on the panel, a second application on the next tapping day is advisable.

The scraping of the panel below the cut to remove overflowed coagulated latex is not to be recommended as a desirable estate practice. The more delicate tissues thereby exposed are more susceptible to disease than the outer corky layers which are the natural protection of the inner growing tissues. For the same reason scraping is not to be recommended as a means of eradicating the epiphytic plants such as lichens and liverworts which may often be seen growing on the trunk of the rubber tree. The presence of such growths usually indicates bad drainage and poor soil conditions. They can be removed by spraying the trunk with Bordeaux mixture, and improving the drainage system.

Ustulina cankers may often be found to damage the lower tapping panels. Such cankers are a menace to the other trees on the estate. They should be cut out to the healthy wood which should then receive a coating of tar or paint consisting of asphaltum and crude creosote heated together in quantities sufficient to give a paint of the desired consistency, approximately 5 lbs. of asphaltum to 15 lbs. of crude creosote.

SUN SCORCH AND DIEBACK OF THE TAPPING PANEL.

Occurrence.

During the wintering season of 1929 many enquiries were received concerning an affection of the tapping panel which showed symptoms somewhat resembling those of Mouldy Rot save that a dark rather than white mould was present. A microscopical examination of the diseased tissue showed the presence of several species of fungi, one or more of which may be present on a single specimen of diseased bark. The Mouldy Rot fungus *Sphaeronema fimbriatum* (E. and H.) Sacc., was not found.

The disease was observed to be most virulent on freshly opened panels on the side of the tree facing the morning sun. When tapping is commenced on the panel it is frequently noted that several wounds are made before the tapper is able to gauge the thickness of the bark It was from such wounds that the dying back of the freshly tapped surface appeared to commence. This wounding and consequent drying up of the exposed tissues during the drought appeared to be the chief causes responsible for the disease. On several estates a further complication arose in that the drought had prolonged the period of wintering and at the same time had favoured the activities of the *Oidium sp.* on the leaves so that large areas had only a sparse foliage until two or three months later when the rains arrived. Trees on these estates suffered badly from sun scorch and die-back of the panel.

The disease was reported as early as 1923 by Thompson (13) Sanderson and Sutcliffe (14) La Rue and Bartlett (15) and Steinman (14). It is generally agreed that the disease is of physiological

origin occurring during dry seasons especially on weak trees with too thin bark which has been tapped too deeply.

Symptoms.

The recently tapped cortex dries up first in small patches of varying size, which later enlarge and coalesce to form narrow bands of dead brown tissue just above the tapping cut. The underlying wood may also become discoloured, usually brown, with darker shallow lines running vertically through the dead patch. On the dead cortical tissue various saprophytic and weakly parasitic fungi appear, and the tissue assumes a dense black colour. These fungi aggravate the disease so that in time large wounds are left on the tapped surface very similar to those caused by Mouldy Rot if neglected.

Cause.

The cause is thought to be entirely physiological. The delicate tissues of the inner cortex exposed by tapping die back, or dry up, during periods of drought when the foliage is insufficient to provide adequate shade for the panel. This condition is more serious when the panel faces the morning sun, when the panel has just been opened, and when tapping is very deep.

Several species of fungi may be associated with the disease, but are to be considered as of secondary importance only. These are in order of the degree of parasitism exhibited on the panel as follows:—

Diplodia Theobromae (Pat) Nowell
Helminthosporium Heveae (Petch)
Cladosporium sp.
Pestallozzia palmarum, Cooke.
Penicillium sp.
Graphium sp.

Descriptive paragraphs and illustrations of spore forms for identification purposes are given later. It should be mentioned here that the *Graphium sp.* which commonly occurs on the tapping cut, vertical channel bark scrap and earth scrap has a fruiting structure resembling the pycnidium of *Sphaeronema fimbriatum* but differs from it in that the spores are produced in globular form at the end of a column of hyphae, and not within a flask-shaped structure as in *Sphaeronema sp.* A comparison of the illustrations will show this. (Cf. Fig. 7 Page 269 and Plate V). To the naked eye or through a hand lens they are almost indistinguishable in nature.

Control.

Rest from tapping until the drought ends, or if during wintering, until the foliage becomes sufficient to provide ample shade for the panel. Apply a smear of Cargilineum "B" mixture (10 per cent.) to the freshly tapped panel, at intervals of one week, and continue

until the drought ends. Always open tapping on the original cut and tap less deeply for a time. Experience shows that the application of water miscible disinfectant is of little use, probably due to the fact that the drying tissues absorb the disinfectant too deeply, resulting in further death of the cambium and aggravation of the disease.

Preventive measures should always be adopted just previous to and during wintering. Tap less deeply, cease tapping on exposed situations during wintering and avoid opening fresh cuts on a panel facing the morning sun.

Other methods of control have been practised in various districts. Jodelite, 10 per cent. Tar, 90 per cent. Dougalite, 10 per cent. Tar, 90 per cent. or Brunolinum, 10 per cent. + Tar 90 per cent. are mixtures which have been used with success on the panel to prevent drying out, and to protect the tissues from infections by fungi and bacteria.

FUNGI IDENTIFIED ON TAPPING PANNEL.

The following description of the fungi commonly occurring as weak parasites on the tapping panel should be read in conjunction with the line-drawings of spore forms on page.269

Fig. 1. *Fusarium* sp. (Group Martiella) occurs on the tapping panel in association with *Sphaeronema fimbriatum* (E. and H.) Sacc., or alone in wet weather. Three common spore types, microconidia sub-rounded or tapering elliptical averaging 5.12 x 2.35 μ, borne in clusters or heads terminal on short, rarely branched conidiophores, macroconidia borne singly or in groups of 2 or 3 terminally on short branched conidiophores 48 μ long, spores 1 to 4 septate averaging 15—36 μ long 2.4—6 μ broad, Chlamydospores terminal and intercalary. Dark coloured sclerotia—like bodies also occur. Illustration shows single celled microconidia, septate macroconidia and chlamydospores.

Fig. 2. *Diplodia Theobromae* (Pat) Nowell. occurs on the tapping panel in association with scorching, die-back and wounding, also common in die-back of stems of many host plants. Pycnidia small submerged, scattered or aggregated in a smooth stroma or on a stroma covered with dark brown mycelium, erupent carbonous, black, usually ostiolate, lenticular to flask-shaped; conidia ellipsoid to ovate, rounded at both ends, colourless, non-septate when young, uniseptate, not constricted, blackish-brown when mature averaging 24 to 30 by 16 μ; paraphyses abundant, average 60 μ long. The fungus was first described by Patouillard in 1892 under the name *Botryodiplodia Theobromae*, since then it has been described under many synonyms.

Fig. 3. *Helminthosporium Heveae* (Petch) is known primarily as the cause of Bird's Eye Spot of leaves, but is also a wound parasite of stems, hence its occurrence on the tapping panel. Conidiophores simple, scattered, olivaceous 70—200 μ long; conidia cymbriform 3—10 septate brown 50—120 by 10—16 μ. In culture on agar media the small less septate spore is produced.

Fig. 4. *Cladosporium sp.* Common saprophyte on leaves and tapping panel as a brownish mould. Conidiospores in dense clusters sparingly branched, septate, nodulose. Conidia elliptic to oblong 1—4 septate, tawny, averaging 10 to 20 by 4 μ.

Fig. 5. *Pestalozzia palmarum,* Cooke, Weak parasite of leaf and stem. Acervuli flattened to erumpent, dark coloured, submerged; spores fusiform 4 septate; terminal cells hyaline with three hyaline setae 25—30 μ long, basal cell bearing short appendage middle three cells dark brown, 12—18 by 5—10 μ, inclusive of the two hyaline cells average 18—25 by 5 x 10 μ in size.

Fig. 6. *Penicillium sp.* Common saprophytes on dead tissues. Species undetermined. Conidiophores floccose and spreading, conidia ovate to elliptical, greenish, 2—4 by 2.3 μ.

Fig. 7. *Graphium sp.* Saprophyte on dead tissues. Synnema stalked, fibrous with fimbriated apex, dark brown, 250 to 350 μ long enclosing cylinder of colourless hyphae at the end of which conidia are borne, forming a colourless waxy globule at the apex of the synnema. Conidia ovoid to oblong, colourless, minute, 3 to 4 by 2 to 2.5 μ.

Conclusions.

In the above pages a description is given of the more serious diseases of the tapping panel, save that of Brown Bast, methods for the control of which were given on pages 64—66 of the R.R.I. Annual Report for 1928. It is pointed out that it is necessary seriously to wound the rubber tree in order to withdraw the latex. Under ordinary circumstances some protection should be given to that wounded portion of the trunk in the same way that pruning wounds are protected by painting over the cut surfaces with some substance that will prevent attack by parasitic organisms. It is known, however, that plants possess the power to heal wounds by natural processes provided reasonable time is allowed. For several days before the plant has time to cover its wounded surfaces with a protective layer of cork, as in the case of the tapped surfaces of the rubber tree, it is open to attack by parasitic organisms. The danger from such infection can best be minimised by the adoption of modern sanitary estate practices so as to maintain a high state of health and vigour of the tree, and removal of dead logs or other infective material which is often to be found lying about in badly managed estates.

Disease usually becomes more epidemic in a crop if grown on extensive plantation system than it would in the same crop grown in isolated areas separated from each other by natural boundaries or other plants not hosts of fungi which cause the disease. Hence, when a very infective disease breaks out on a plantation it is necessary to adopt extensive measures of control so that all plants in an area around the one infected plant become suspect and are treated accordingly.

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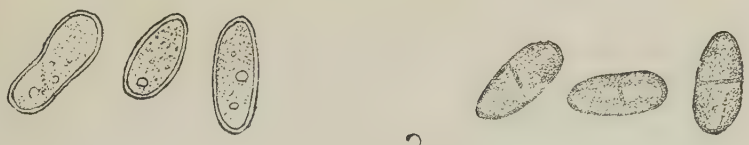

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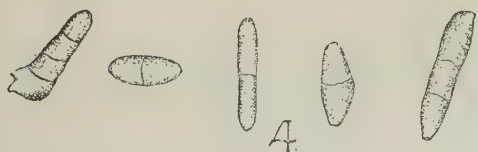

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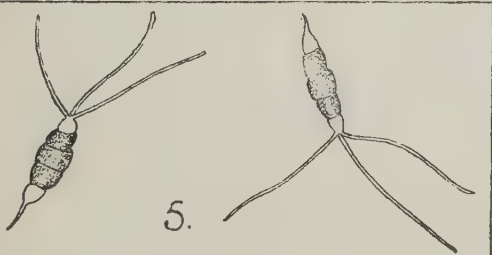

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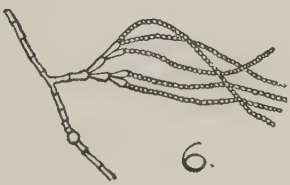

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7.

A regular monthly painting of the tapping panel with a disinfectant medium has been adopted on some estates to serve both as a preventive measure and as a check on bark consumption. This may be advantageous, but the fact that after each monthly treatment the next day's tapping exposes tissue which is readily subject to attack by fungi, and that unless a keen watch is kept may ravage the panel and be carried to other panels for nearly a month before the regular treatment is again given, shows that this method might give a very false feeling of security from disease.

A better method is to instruct all tappers to report any abnormal appearances on the panel. These should then be inspected and suitable remedial measures carried out by the diseases and pests gang.

There is no necessity at present to adopt periodical preventive treatment of the panel. Everything possible should be done however to assist the natural healing processes of the tree by maintaining the estate in as good a state of cultivation, sanitation and drainage as is commercially possible.

Bearing these points in mind and having a knowledge of the symptoms and control of disease, extensive losses from diseases of the tapping panel will be very improbable.

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DESCRIPTION OF PLATES.

Plate. I.

Fig. I. *Black Stripe.* Tapping cut showing early symptoms of attack. Three vertical black stripes are already visible in the middle of the picture.

Fig. 2. *Black Stripe.* Showing more advanced stages of the disease. The black stripes have continued down with the cut, while the regions of earlier infection have begun to heal and a callus has formed around the wounds.

Plate. II.

Fig. 1. *Mouldy Rot of the Tapping Panel.* Immediately above the cut the white felt-like mould is visible. The upper portion of the tapped panel shows the wounding effect of the continued activity of fungus. This panel had been treated repeatedly by strip painting with disinfectant.

Plate. III.

Mouldy Rot. Section of affected cortex showing the mycelium and resting spores of *Sphaeronema fimbriatum* (E. and H.) Sacc. on the surface and in the tissues. x 160.

Plate. IV.

Fig. 1. *Mouldy Rot. Sphaeronema fimbriatum* (E. and H.) Sacc, specimen of Mould from the tapping panel consists almost entirely of endoconidia of *Sphaeronema* together with bacteria and a single spore of *Fusarium.* x 1000.

Fig. 11. Germinating endoconidia of *Sphaeronema.* Endoconidia are produced in large numbers on the panel even in dry weather. Culture of the fungus in the laboratory, on media containing various quantities of disinfectant, showed that growth consists entirely of this form of spore at concentrations strong enough to prevent the germination of the resting spore. The endoconidia must therefore be regarded as a more important factor in the spread of the disease than hitherto.

PLATE V.

Fig. 1. Pycnidium of *Sphaeronema fimbriatum* from Mouldy Rot. Note the rounded base, smooth neck and mass of spores at the apex. x about 80.

Fig. 11. Pycnidium of *Sphaeronema sp.* from Hevea wood chips. Note elongate base and hirsute neck. x 100.

PLATE VI.

Fig. 1. Section of young pycnidium of *Sphaeronema fimbriatum* from Mouldy Rot. Note nature of contents. x 400.

Fig. 11. White Fan Blight on the tapping panel showing fungus growing above and below the cut.

Plates I, II, III, Plate V Fig. I, Plate VI Fig. II are from originals by Mr. H. Sutcliffe and are reproduced here by kind permission of the Rubber Growers' Association in whose journals they have previously appeared.

The remaining plates are by Mr. H. Gunnery. The writer wishes to extend to the above thanks and appreciation for the help they have given, and to Mr. A. R. Sanderson for helpful suggestions during compilation.

PLATE I.

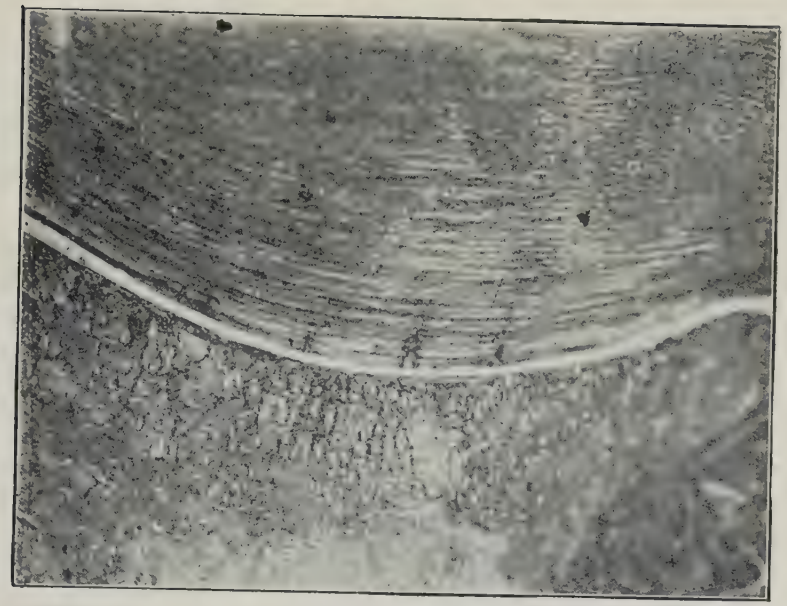
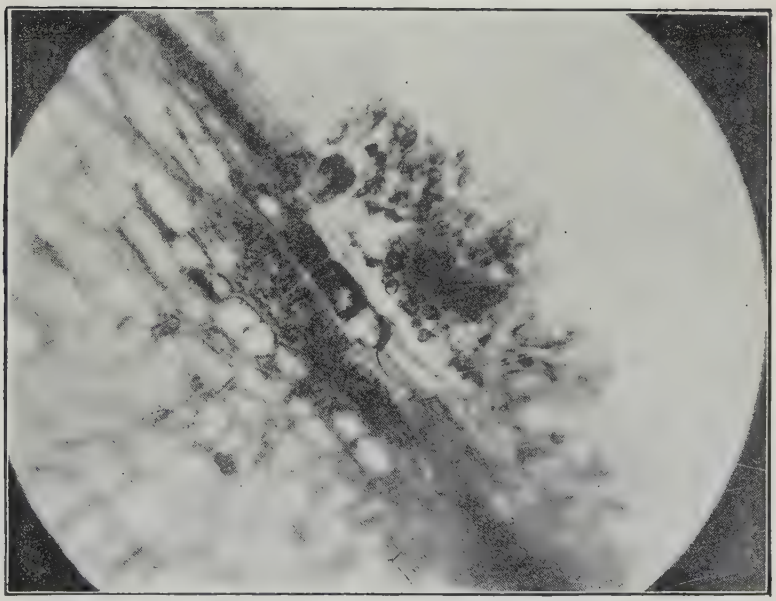


Fig. 1.

Fig. 2.

PLATE II.

PLATE III.



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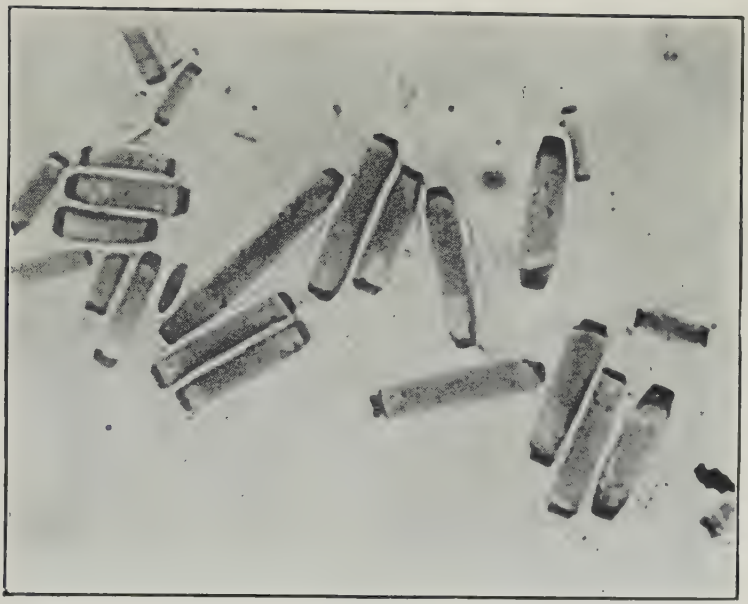

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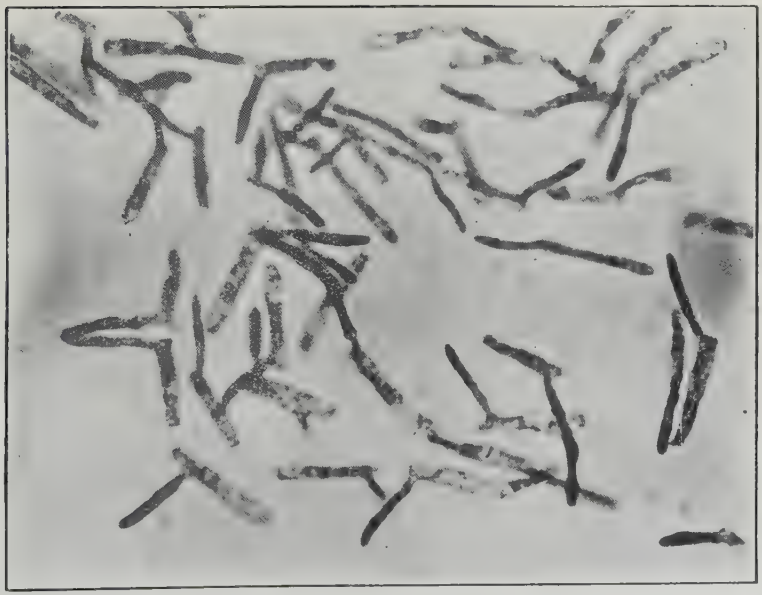

Fig. 2.

PLATE V.

Fig. 1.

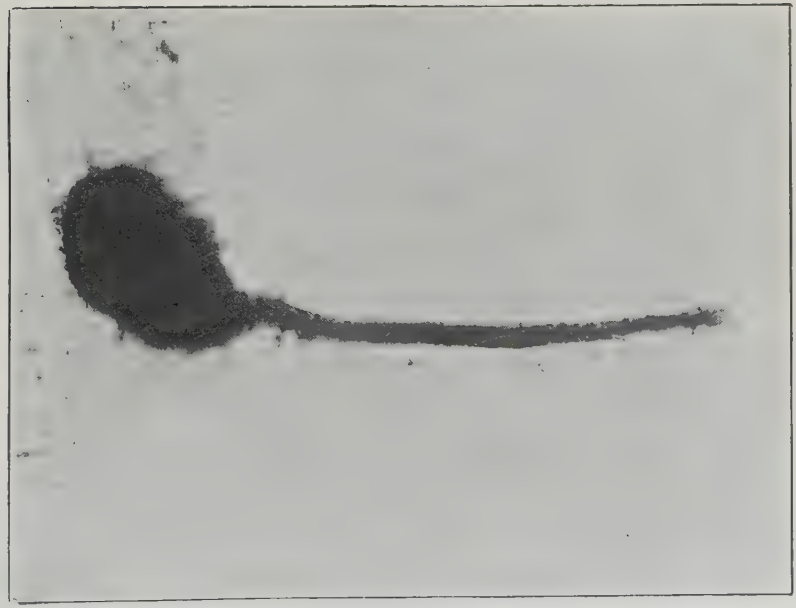

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PLATE VI.

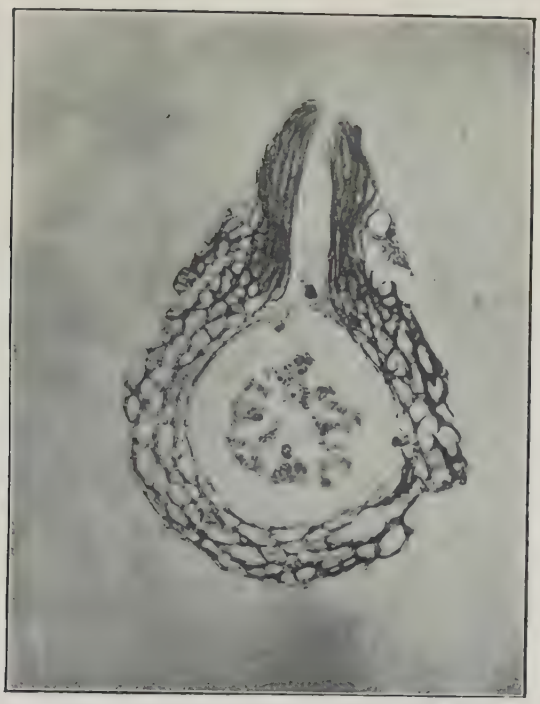

Fig. 1.

Fig. 2.

NATIVE RUBBER PRODUCTION

IN

THE NETHERLANDS EAST INDIES.

In 1924 the Native Rubber Industries Investigation Committee was formed and several delegations were sent to the important native rubber producing districts in various parts of the Netherlands East Indies, in co-operation with the Department of Agriculture, Industries and Commerce, N.E.I. to collect information concerning areas under rubber cultivation and output of rubber.

Six reports (Nos. I—VI) prepared by this Committee were published between 1924 and 1927 entitled "Native Rubber Cultivation in the Netherlands East Indies". A summarising final report (No. VII) was also published. The investigation was then taken over by the Department of Agriculture, Industries and Commerce N.E.I. and the more recent results of the enquiry are being published from time to time in the publication "Korte Berichten voor Landbouw, Nijverheid en Handel". The data on which these reports are based are derived from export figures of the principal rubber districts and returns received from the Residents of the Provinces in co-operation with their Agricultural Advisers. In addition, the Staff of the Division of Agricultural Economics visit the districts at definite periods in order to keep in touch with developments.

The information contained in this article is abstracted from the Third Report on Native Rubber, June 1929, by A. Luytjes and G. C. W. Chr. Tergast published in "Korte Berichten voor Landbouw Nijverheid en Handel", July 10th 1929, No. 29 and reprinted as a separate pamphlet in English.

No reliable data exists as to the area planted with native rubber, owing to lack of survey figures, so that the export of raw rubber is used as the most suitable starting point for the estimation of cultivated area.

More exact figures of export have been available during the last few years owing to (a) the introduction of an export duty on rubber (May 1925), (b) control of the moisture and dirt content of the exported rubber, (c) the introduction in January 1928 by the Central Office of Statistics of new statistics to correspond with the rubber valuation for the levy of export duty by dividing the exported rubber into three classes viz. (i) all dry rubber which has been machined (ii) raw, unpurified scrap and earth rubber, (iii) all other native rubber not included in (i) or (ii).

The moisture content for each of these groups can be fairly well estimated for each province, so that the accuracy of the dry weight figures has improved considerably.

Complete accuracy is not yet possible, since the figures refer only to rubber on which export duty is paid. These figures exclude (1) estate rubber (2) inter-island shipments which are small (3) transport of rubber from outer possessions to Java which is also small for native rubber. (In 1928, the figure was only 1663 tons which was chiefly estate rubber) (4) native rubber exported to foreign countries on certificate; as far as is known this only takes place in Tapanuli for native holdings equipped as estates. Arrivals of native rubber at the ports of Bengkalis and Selatpandjang which are re-exported, are included in the statistics of Sumatra E.C.

Figures of the moisture content of the three groups of rubber from the different provinces, which need not be reproduced here, are given, to show the method of computation. These show a moisture content in group ii of 50 per cent. in seven provices, 40 per cent. in three provinces and 33 per cent. in three other provinces.

In Group iii the moisture content varies from 15 to 33 per cent., the average being about 27 per cent.

On the data obtained the export of native rubber in 1927 and 1928 is estimated as accurately as possible in Table I.

TABLE I.

(Exports of native rubber to foreign countries, in tons of 1000 kg.)

Districts.	1928. (Quantity for each group.) I	II	III	Total wet.	Dry equivalent.	Per cent.	1927. Dry equivalent.	Per cent.
Sumatra's O. K.	1,663	1,578	16,175	18,841[1]	12,845[1]	68,	14,424[2]	70
Atjeh	42	40	420	502	426	84,8		
Tapanoelid	1,846	49	548	2,443	2,236	91,5	3,563	74
,, (no export duty)	...	...	...	472	432	91,5		
Sumatra's W. K	149	14	519	682	574	84	1,093	85
Riouw & O: Indragiri	462	1,244	6,559	8,265	7,194	87	7,787	85
,, ijgebied	...	...	..	1,008	672	66,6	52	65
Djambi	1,717	1,058	30,465	33,240	19,610	58,9	19,322	50
Palembang	2,296	2,276	13,345	17,917	12,509	69,8	15,082	68
Benkoelen	...	...	4	4	3	75	23	85
Banka	203	76	399	678	480	70,7	12	65
Billiton	78	26	...	104	94	90,3	55	65
W. afd. v. Borneo	6,029	867	14,138	21,034	16,648	79,1	...	75
Z. & O. afd. v. Borneo	4,007	532	19,449	23,988	17,239	71,9	...	70
Lamp. Distr.	...	...	...	...	...	...	...	65
	18,492	7,760	102,021	129,178	90,962	70,4	98,683	66

(1) Except the import from foreign countries into the ports of Bengkalis and Selatpandjang, viz 575 tons wet = 391 tons dry.

(2) Revised figure, including excess of exports of Bengkalis and Stlatpandjang, during June—December, 1927.

The table shows a diminished loss due to moisture content in 1928 compared with 1927; this is due partly to a stricter application of the bye-laws and partly to the treatment of larger quantities of native rubber in local "refining" factories. It should also be remembered that, in connection with the exports from Sumatra E.C., until June 1927 Bengkalis and Selatpandjang were free ports and subsequently were annexed to the Customs area.

The figures for these ports are only partly included in 1927 and wholly in 1928.

During 1928 the exports from these ports amounted to 2933 tons of dry rubber.

In comparing also the exports from Sumatra E.C. and Acheen with the total exports from the Netherlands East Indies the exports from the above mentioned ports should not be included.

The corrected figures in Table I for Acheen and Sumatra should be:—

1927 14,424 — 1,665 = 12,759 tons.
1928 12,845 — 2,933 + 426 (Acheen) = 10,338 tons.

The corrected figures for the Netherlands East Indies should be:—

1927 98,683 — 1,665 = 97,018 tons.
1928 90,962 — 2,933 = 88,029 tons.

Decrease in 1928 took place in nearly all districts, especially where cultivations other than rubber were of importance. Only Djambi, which is dependent chiefly on rubber cultivation, shows an increase.

The more detailed monthly figures, which need not be reproduced here, show the effect of a falling price on export; decrease of export is not due to a decrease of production. The tendency is for the local population to carry on tapping operations rather than to obtain imported tappers. This tendency is enhanced by the large extensions of rubber cultivation coming into production from 1924 onwards.

Many of the casual tappers now have their own holdings and these changes have caused the population to adapt themselves to the lower price levels, while the slightly higher levels from January 1929 have maintained this situation, except in districts where crops other than rubber are also cultivated.

SUMMARY.

The present position in regard to native holdings may be summarised as follows:—

(i) The area not yet in bearing is in most districts at least twice or three times the area in bearing. The younger holdings date mostly from 1924 to 1928. New plantings have lately been reduced on account of the areas already planted and the low price level.

(ii) The potential annual production is at present estimated at 125,000 tons and will amount to about 135,000 tons at the end of 1929 with subsequent increase.

(iii) Many imported tappers left the districts, except in Djambi in 1928, owing to low prices. Tapping by the owners and their families and employment of local labour has increased, owing to the increasing number of owners of small holdings thus enabling the cultivators to adapt themselves to low prices.

(iv) Fluctuations of price and production suggest that, at a constant price of 1 shilling per pound, the population will tap as much as possible, except in districts where other crops are grown (Tapanuli, West Coast of Sumatra and Banka).

(v) The potential production has not yet been obtained from trees already mature, owing to shortage of labour.

A rise in price will attract labour from outside and also the more intensive employment of local labour, thus causing an increase in production.

REVIEW.

THE TROPICAL CROPS by Otis Warren Barrett, B.Sc., Agricultural Director, Department of Agriculture and Labour, Porto Rico. Publishers: The Macmillan Company, New York. Price 17/- 445 pages including index and 24 plates.

This book is one of "The Rural Science Series" edited by L. H. Bailey.

In his Preface the Author states "Technical treatises there are for "specialists in the various lines of work, but the available accurate infor- "mation, presented in readable and comprehensible form for the average "individual interested in getting the precise correlation of data concerning "the basic factors in great tropical dependencies and the commodities "on which they depend, is not sufficiently in evidence".—'In presenting "the data the author has had two purposes constantly in mind. In the "first place an effort has been made to confine the treatment of the subject "matter very largely to first hand observed information in the conviction "that hearsay ideas and evidence are always liable to more or less distor- "tion through long distance transmission and misunderstandings."

In reviewing a comprehensive book of this character the reviewer naturally turns first to the sections dealing with those crops with which he is familiar in order to see whether the information is accurate and sound. If the information is not considered accurate the reviewer naturally suspects the information in regard to those crops with which he is not so familiar.

Although the book is written in a very interesting and attractive manner, apart from certain American terms and phrases with which the reviewer is not familiar, some of the information in respect of certain crops is not accurate or sound, in spite of the statements in the Preface which are quoted above. The book is admittedly not a technical treatise, but this does not absolve the author from verifying the information by reference to technical literature or to scientific officers having first hand information of the particular crops.

Chapters I, II and III, dealing with tropical field practices and conditions, geography and climate of tropical regions, living conditions for tropical planters, contain useful and valuable information presented in an attractive manner.

In the chapter on coconuts, the Malay is described as the manufacturer of toddy, the fermented liquor prepared from the sap by "tapping" the unopened flower spadix. The author is probably unaware that the Malay, being a Mohammedan, does not touch alcoholic beverages. The Malay makes either a palm sugar by evaporation of the fresh sap or ferments the sap to vinegar.

The fermented alcoholic sap known as "toddy" is prepared in Malaya by Tamils who are great toddy drinkers. Arrack, (distilled toddy) is not prepared in Malaya.

In the chapter on Oil Palms and later in the chapter on Rubber, the author states that the oil palm can be grown on poor soils unsuitable for rubber. This is entirely erroneous; oil palms require soil as rich if not richer than rubber trees (Hevea species).

It is also stated that "$40/- (presumably gold) brings an acre into bearing, clearing, planting and cleaning for five years." This sum is very

inadequate in Malaya. The formation of free fatty acid in the oil in fruit which has deteriorated is due to an enzyme and not to oxidation.

Numerous serious errors occur in the chapter on Rubber.

In discussing the function of latex in the tree, and the lack of knowledge on this subject, the author might equally apply his remarks to many other plant products e.g. turpentine, resin, quinine,—since we do not yet know the functions of these.

The author describes bamboo pots for raising seedlings for transplanting to the field as the safest method. In the East Indies small baskets are used; they are comparatively cheap and rot in situ when the seedlings are transplanted in the field.

The method of transplanting from germination beds to nurseries as described is not usually practised, except for special seed or for establishing multiplication nurseries.

Seedlings in the nursery are never shaded up to two years old, in fact they should not remain in the nurseries until this age.

Root fungi from jungle stumps are so universal that the author's recommendation to send a mycologist with others to select a plantation site has little to recommend it.

Under grafting (P. 309) the author states:—"Sprig buds,————are safest, ¾ to 1½ inches from ready-to-flush-cions". This is somewhat obscure to the English reader.

He also states that "seed selection is much simpler (than grafting) that it will be practised in all but the very advanced plantations"—this also is misleading and incorrect.

Later "Bearing trees may be cut back and the stump sprouts budded when of proper age, 9 to 12 months". Presumably this refers to pollarding of mother trees in order to obtain budwood, but the meaning is obscure.

On p. 312 under Tapping, the author states "When the capsules form and explode, the tapper may begin the blood-letting work". The first production of seed is never taken as a criterion of tappable age.

Half herring bone tapping described on p. 312 was abandoned several years ago on all estates except native holdings—this term is not applied to a one cut system. Only in Ceylon is the bark shaving removed in tapping as thin as 1/32 inch. Malayan and Sumatran practice is nearer 1/20 inch. Tapped areas certainly cannot be retapped after six months—the more usual renewal period is 4-6 years. A tapper may be able to make 1,000 to 1,500 cuts a day but this would not be an economic procedure, since he would be tapping too late. The more usual number is not more than 350 to 400 and this is now being reduced, in order to obtain more latex by completing tapping earlier.

Crepe rubber is never dried in a smokehouse as described on p. 315—this applies only to sheet.

The statement that "Cyanogenetic glucocides (in rubber seeds) are estimated at 0.02 hydrocyanic acid," without any other reference would be unintelligible except to those who know that the seeds contain this toxic substance equivalent in quantity to 0.02 per cent. of hydrocyanic acid.

In connection with leaf diseases—the author makes no mention of the very serious Oidium but refers to Phytophthora Meadii and Faberi which are not very important in Malaya as leaf diseases. Root diseases are certainly far more serious in Malaya at present than leaf diseases.

The reviewer has quoted the above statements in order to illustrate some serious errors which should not occur even in a "popular" book

written by an author who has admittedly a reputation in tropical agriculture. It is impossible for an author of such a comprehensive volume to have first hand acquaintance with all the crops discussed but a writer who attempts this cannot be absolved if he does not first refer his work to acknowledged experts on those crops of which he has not first hand information since he may be led astray even by reading some of the technical literature on the particular subject.

In spite of these errors and probably others of a similar nature the book is very readable as a popular volume on a vast subject covering many countries and climates of the important tropical regions.

B.J.E.